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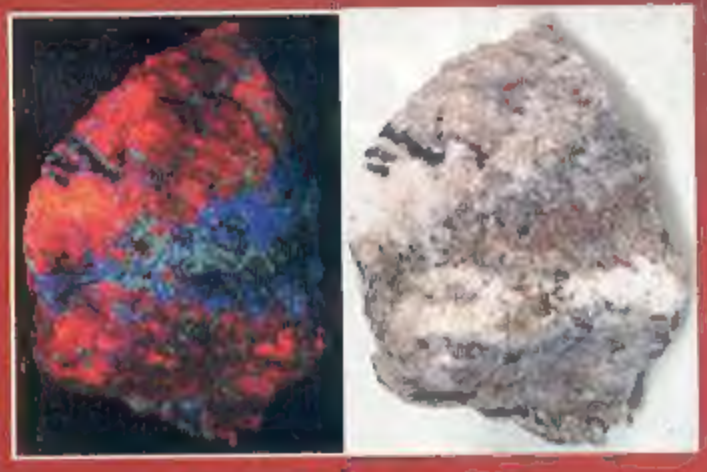

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COVER: This brilliant blue specimen of azurite from Bisbee, Arizona, is in the John Barlow Collection. (Photo by Earl Lewis)

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THE FRUGAL COLLECTOR

These Copper Minerals Add Color to Your Collection

by Bob Jones

In the first three articles of this series, I described barite, pyrite and gypsum. All are quite common and easily obtained at a reasonable price. In this article, I will cover two nearly inseparable minerals, azurite and malachite. You're probably thinking these two very colorful minerals are out of your price range. Not so! And you may wonder why I'm describing two minerals in one article. Simple! They almost always occur together, and their chemistry is best explained by comparing one with the other.

I would be the first to admit that there are plenty of high-priced azurites. The same is true of malachite, especially when it takes a notion to pseudomorph itself after azurite crystals. Still, any number of fine azurite/malachite specimens of modest size and price, all of them with fine color, are on the market, and with careful searching, a Frugal Collector can add bright color to a collection of barites, selenites, calcites, and quartzes (the latter two will be the subjects of future articles).

If you read mineral literature at all, you know that the occurrences of azurite and malachite are very limited as compared to things like selenite gypsum, quartz, and calcite. They occur almost exclusively in and around copper ore deposits, and these are fairly restricted in scope. Still, the regions that do produce fine copper carbonate minerals have been exceedingly prolific, and since both azurite and malachite are very attractive, specimens have been diligently salvaged by miners and collectors.

For example, it seemed every house in Bisbee, Arizona, and every store along Brewery Gulch and Main Street had at least a small suite of colorful copper minerals on display. Some of the finest specimens were displayed in the local banks! It

Azurite

Some of the most pleasing azurite is the soft blue velvety variety, here coating stalactites (Evan Jones collection). (Photos by the author)

Layers of gemmy azurite and malachite make this specimen from the Larson collection something special.

and Malachite

What could be more beautiful than an azurite geode holding a lovely feather of malachite (J. Vacek collection)?

This velvet malachite on native copper is from Beresov, Russia.

is not uncommon for some of this "salvaged" material to reach the market even today. Old miners' collections get sold by their descendents. Boxes of minerals are found in attics and cellars, and the mines are still accessible to those who choose to risk arrest or injury by sneaking into any one of the many adits scattered around the slopes of the Mule Mountains.

While you may pass up a small selenite crystal as too small to bother with, I doubt you would do the same for similar small, blue or green specimens of these copper companions.

The source of virtually all azurite and malachite is, logically, any deposit rich in copper, especially those deposits located in desert climates, where weathering penetrates to great depths. It is weathering that plays the major role in changing copper sulfides into the very colorful secondary copper species we love. At Bisbee, for example, weathering has penetrated to at least 1,000 feet, so the production of azurite went on for decades.

In one unique case, at Tsumeb, Namibia, two oxide zones were developed from weathering. (The name Tsumeb means something like "green hill" in the local vernacular.) One was the usual surface gossan region. This upper oxide zone extended from the surface to well over 1,000 feet underground. A second oxide zone, with a new batch of azurites, malachite, cerussite, dioptase, and more secondary minerals, was found well over 2,500 feet below the surface.

Both azurite and malachite are hydrous copper carbonates, and their chemistries are almost, but not quite, the same. That "not quite" is significant, because it is why the two minerals have such different colors. It is also why malachite is far more common than azurite, and why it replaces azurite much more often than the reverse.

Azurite is composed of three elements. The main metal is copper. Three atoms are needed to form one azurite molecule. Each of these copper atoms has a valence of 2+. This means there are two electrons with each atom to combine with something in a chemical reaction. The "something" in this case is carbon dioxide. In the azurite molecule, there are two such carbon dioxide molecules, each consisting of carbon and two oxygen atoms. Finally, two hydroxyl radicals made up of one oxygen and one hydrogen atom complete the azurite molecule.

continued on next page

Malachite is also composed of three copper ions, each with a valence of two electrons. These combine with only one carbon dioxide molecule and the usual two hydroxyl radicals. So, the chemical difference between azurite and malachite is simply one molecule of carbon dioxide.

Can the lack of just one molecule of carbon dioxide make such an internal change as to cause a color difference? Absolutely, because this is not only a change in the composition of the molecule, but a change in the internal atomic structure and how these components relate to each other! Not only does the color change from blue to green, but there is also an improvement in the stability of the mineral. That extra carbon dioxide molecule in azurite makes it a little more unstable. Nature loves stability, so given an opportunity, azurite will divest itself of that extra carbon dioxide to become more stable. When it does, a chameleon change occurs, and the result is green malachite, a more stable form of the copper carbonate structure. And that explains not only why there is more malachite than azurite, but why there are more malachite pseudomorphs after azurite than the reverse.

Azurite and malachite form when primary copper sulfides like chalcopyrite are attacked by weathering. These primary species decompose and release copper ions. If the host rock is limestone, a ready source of carbon dioxide, nature has what it needs to join the copper ions. Even if there is no limestone, the atmosphere itself has a small percentage of carbon dioxide, which can be absorbed. Bring the two together—copper ions and carbon dioxide—and the stage is set for azurite or malachite development.

While these two copper minerals are so similar in chemistry, they certainly maintain a distinguishing difference in appearance. Azurite loves to develop as descrete crystals of generous size. It has been found in a host of varieties based on its normal monoclinic crystal habit. Malachite, on the other hand, prefers to form microscopic, needlelike crystals, and seldom forms crystals of descrete size. Descrete crystals are called primary malachite to distinguish them from malachite pseudomorphs. This designation also suggests they developed directly from copper-rich solutions. The massive malachite the lapidary enjoys so much may look solid, but is actually tightly compacted, fine needle crystals so tightly bonded they seem solid.

Another obvious difference between the two is that malachite is far more abundant, with much of it in massive form and cuttable. Remember, malachite is more stable and much of what we see may have started out as azurite. Azurite, on the other hand, seldom forms in solid masses that can be used by the lapidary. These blue-green twins are not the only secondary minerals that form in copper deposits. They are, however, the most common.

Azurite forms monoclinic crystals. They can be as simple as a single blade shaped like a small sword, or be so complex you can hardly count the modifying faces. The color can range from almost black (which is an electric blue in thin section) to a lovely pale blue. The finest pale blue azurite is seen as soft, velvety coatings showing a botryoidal surface. It is so soft it will crush at a touch. Quantities of this very lovely azurite have been mined in Bisbee. These crystals of azurite are microscopic, so the surface looks like a piece of blue cloth.

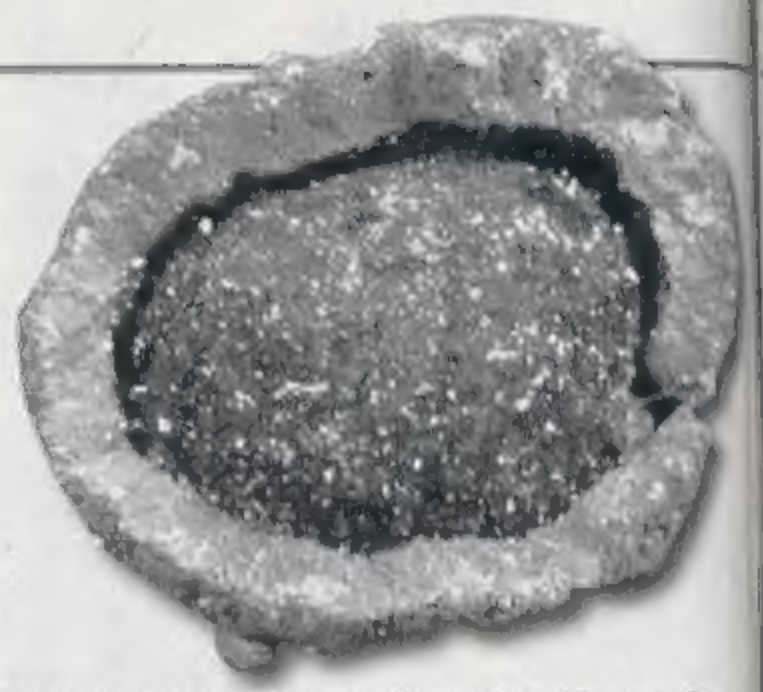
The azurites that develop into descrete crystals can exceed a foot in length. Most azurites are seen in blocky, sometimes almost equidimensional habit. The crystals may be in thick clusters or single free-standing blades. Some of the nicest crystals are single small blades scattered over the surface of light-brown, botryoidal iron oxide. Many of these crystals show a curving habit and, when clustered together, form roselike groupings. Sometimes, the background will be a black matrix that provides nice contrast to the copper carbonate blades. Some of the nicest azurite specimens have a touch of green velvet malachite, evidence of partial alteration. Such specimens are not necessarily extremely valuable if the crystals are not huge. These are the ones the Frugal Collector might watch for.

Another type of azurite I particularly like came out of Zacatecas, Mexico, years ago. The azurite crystals were never large—maybe an inch long—but tight, radiating clusters of thin blades covering the matrix. Each crystal stood individually, with small sections completely covered with crystals.

What made the Zacatecas azurites special to me was that they all showed a trace of malachite in radiating crystal form within each crystal, evidence of pseudomorphing. This made for a lovely contrast. These specimens never got the high-priced respect granted to specimens from Bisbee, Morenci, Chessy, France, the Urals or Tsumeb. Yet, their brilliant luster, perfect prismatic crystal form, and contrasting colors made these small azurite blades seem larger than life. Quantities of these sweet specimens were brought out of Mexico years ago. Luckily, they are still seen on dealers' tables at shows.

The earliest azurites mined could well have come from China or the Sinai Desert. The Chinese have been making bronze, an alloy of copper and tin, for centuries. The Egyptians mined malachite, azurite and turquoise from the Sinai using slaves. These minerals were used primarily for decorative purposes, sometimes as makeup, and more often in pottery glazes to give the fired clay a green tint.

In fact, we suspect it was through the use of malachite as a coloring glaze in pottery making that the red metal copper was accidentally smelted for the first time. Imagine the surprise of some potter when he put a nice



A delightful, small geode of azurite holds a perfect sphere of azurite crystals and comes from the Blue Ball Mine in Arizona (J. Vacek collection).

clay pot coated with malachite powder in his kiln, only to get the fire too hot and spoil the effect. He would be even more surprised if he noticed the small beads of red metal—copper the excess heat had released from the malachite—in the kiln bottom.

While the Chinese undoubtedly mined vast amounts of copper, from which they cast huge bronze vessels and artifacts, we have little proof of their discovery of azurite and malachite. You can be sure, however, they had to have used azurite, malachite, and other copper oxides to get their red metal in the earliest days of metallurgy in China.

In the last 30 years, however, China has become a major source of fine azurite. The first azurites to come from China in recent years were lovely, blue crystal "roses." These rounded clusters of crystals often look like thick, blue flower petal arrangements. Priced high, these clusters sold readily. Today, the enthusiasm for Chinese azurites has diminished some, as many collectors already have a good specimen. That means the Frugal Collector has a better chance of finding a nice Chinese azurite cluster at a reasonable price.

America's major source of azurite is Arizona. In this state, Morenci, Bisbee, Ajo, Ray, Globe, and even Bagdad have been major producers. Except for Morenci, however, these ore deposits have been largely worked out. You might think that means there are few azurites on the market today. Not so! Bisbee was especially prolific. With a deep weathered zone exceeding 1,000 feet, Bisbee began producing superb azurites almost from the day it was opened in the 1870s, and continued to do so to the very end.

It's interesting to note that when the mine managers later perfected the technique of smelting lower-grade sulfide ores at a profit, they switched to mining the sulfides, since they were in greater abundance. This put the oxide ores in a secondary role in the production of copper. As long as the sulfide ores could be mined for a profit, the oxide ores were held back to be used to raise production figures during hard times! That meant the occasional enterprising miner or slippery collector could invade the oxide

ore pile or zone and gather certain blue or green goodies.

The first copper mine opened in Bisbee was the Copper Queen, which became famous for its azurites and other copper species—more than 300 of them! During mining, workers actually broke into huge limestone cavities, sometimes lined with lovely azurite crystals. One such was called the Jewel Box. Another such amazing cavern was prepared so luncheons could be served to prospective investors in it.

The funny thing is the Copper Queen Mine almost never happened. Early development failed to find any major ore deposits and financing of the project was diminishing rapidly. In fact, the mine manager was ordered to make one more exploratory blast, and if a pay ore was not found, to close down. Luckily, that final blast cut into an extremely rich copper zone and the Copper Queen Mine came on line.

The first mine manager was a man who had not only vast experience in mining, but an eye for fine minerals. The man was Ben Williams, from Swansea, Wales, where copper smelting was an advanced art long before copper was even discovered in America.

When Ben developed the Copper Queen, he also collected on his journeys underground. Remarkably, his collection has survived. It was apparently crated up upon his death and came to light just a few years ago. Some of the specimens from his collection are now in the Evan Jones collection. With a mine manager who had some affection for fine specimens, it is no wonder Bisbee azurites were salvaged in quantity.

Another reason was the fact that A.E. Foote, noted mineral dealer from Philadelphia in the early part of the 20th century, spent time in Arizona buying up copper species and supplied education and museum establishments, as well as private collectors, with them. Tens of thousands of azurites exist today because of the likes of Foote and Williams. Keep in mind that in its first years, the Copper Queen survived because of the richness of the ore—rich because it was all secondary copper species: azurite, malachite, cuprite, and the like. How many tons of fine crystal specimens were shipped to Swansea? Looking at the bright side, the sacrifice of those superb specimens made it possible for many more superb specimens to come to grass during successful mining in later years.

Among the more remarkable specimens out of Bisbee are the malachite pseudomorphs after azurite resulting from that change in chemistry earlier described. It seems odd to me that the vast majority of these malachite pseudomorphs are flat-bladed crystals. Many of them have a slightly concave look, probably because of the loss of those carbon dioxide molecules in the azurite, which changed the crystal volume.

Long before the copper deposits of the Southwest were discovered, copper deposits in Russia's Ural Mountains had already produced vast quantities of malachite and a smaller, but important, stream of azurite crystals. You never see the azurites any more. Small slabs of malachite do show up, but not often. With the opening of Russia's borders, some of this material did break loose. The remarkable copper deposits in the Urals produced more cutting-grade malachite than had ever been found, and saved, before. It wasn't until the copper deposits in Central Africa really opened up 25 years ago that we saw so much fine gem-grade malachite again. Go to any royal palace or estate home in Europe, and you're apt to see objets d'art made from Russian malachite. When I visited the Mining Institute in St. Petersburg, it held several large chunks of Uralian malachite from those good old days. The piece that impressed me most weighed in at over 3,000 pounds!

When Tsumeb was discovered, before World War I, little did anyone realize that it would become one of the world's great specimen producers. In those earliest days, the Tsumeb region was known as German West Africa. One of the significant mine managers in those days was a fellow named Friedrich Kegel. Like Ben Williams in Bisbee, Kegel had a high appreciation for fine minerals. He assembled a large collection, which eventually ended up in the Smithsonian Institution. One terrific azurite he owned is something of a latticework of azurite blades, the largest being over a foot long! You can see it on display today in the Smithsonian Gem and Mineral Gallery.

After World War I, the Germans lost the Tsumeb territory, and it came under the control of the British. Mining continued down through a very deep and rich oxide zone loaded with secondary minerals like azurite, malachite pseudomorphs, dioptase, cerussite, and much more. Then mining reached the water table. Secondary mineralization stopped, and sulfides ruled the ore bins. That signaled the end of the azurites, dioptase, malachite, and other oxide minerals. Still, miners were able to get back into the old upper workings and dig away at what remained of the ore pillars supporting the stope roof. So, a thin but gratifying trickle of fine minerals continued to come from Tsumeb.

As deep mining proceeded, much to everyone's surprise, the miners suddenly breached the sulfide zone and entered yet another zone of secondary oxides. Once again, the mine started producing large quantities of azurite, malachite, cerussite, smithsonite, dioptase, and an entire suite of exceptionally fine and rare minerals. The azurites retrieved during these later decades are still seen around in dealer shops and at shows.

continued on next page

Azurite and Malachite *from page 15*

Why this unique deep oxide zone had occurred had to do with the crustal structure. Hydrothermal solutions had surged up through a major crustal fault to form the original ore body. Later, a second fault, starting some distance away, cut down at an angle and intersected the ore body. This fault brought oxygen-rich surface water down into those lower depths, where it immediately attacked the sulfides, causing secondary mineralization to develop again. This unusual circumstance resulted in additional huge quantities of collector minerals. A lot of those minerals are still available, including azurite!

Certainly, the best European source of azurite and malachite pseudomorphs is a deposit at Chessy, near Lyon, France, where choice clusters and groups of azurite crystals were found in quantity. The azurites are quite superb, with some of them showing the typical malachite replacement process ongoing. Of course, such classics seldom show up these days. Still, the deposit produces another crystal oddity that is still occasionally seen.

While the azurites from Chessy are really fine, what has caught the fancy of collectors for years are the large (to 1 inch) cuprite crystals that were found loose in the clay of the deposit. The cuprites are sharp octahedrons that are complete, showing all four pyramidal faces. A very few of the cuprites are unaltered. Most have either a malachite coating or, even more often, have completely altered to malachite. The finest crystals are green, velvety singles approaching an inch. The Chessy azurites are very scarce and costly, but the small, single malachite pseudos can still be seen on occasion.

Here in Arizona, there's a nifty little deposit of azurite. Small, round geodes of azurite are found in corroding clay. They range from pea-size to maybe 2 inches across. A few may cluster to form larger masses. Most are hollow, with an interior lined with brilliant azurite crystal terminations. A few even have light-green, feathery needle growths of malachite perched inside. The smaller azurite geodes are sliced and polished and mounted as earrings. Larger ones make good gem pendants. When solid, the azurite is crushed and used as blue azure in paint, especially in the Orient. The failing in this is that the crushed azurite is just as subject to alteration as are crystals. Imagine a lovely painting with a once-blue sky turned green!

For collectors who like pseudomorphs, there is another source: the Apex Mine, in St. George, Utah. Here, azurite/malachite formed as coatings on selenite crystal blades. The selenite later was etched away, leaving a hollow, thin, blue-and-green cast of the selenite. Brittle and often broken or incomplete on the ends, these still are quite appealing display pieces, so keep an eye out for these rather unusual azurite/malachite casts.

I've probably given you the impression that malachite is always found accompanying azurite. You know, that's not the case. The Russian mines, which produced some azurite, produced huge quantities of solid, banded malachite, which was used to create marvelous objets d'art.

While this Russian gem-quality malachite has long since vanished from the scene, Zaire charged onto the mineral stage in all its green glory. Tons of the green gem have been mined there in the last several decades—and it is still easily available today—yet, little azurite was found. This copper region was once known as the Roan-Antelope District. It was also once controlled by Belgium, and known as the Belgian Congo. Superb malachite specimens from Zaire ended up in the collection of the Belgian king, and that collection can now be seen in a museum in Turveren, Belgium.

Once this Central African region acquired independence, mining was pursued diligently and marvelous copper species have been coming out: huge cuprites, fine light-blue plancheite, and enough malachite of superb lapidary or gem quality to satisfy every lapidary in the world! The material is superbly banded, in classic botryoidal form, and very solid, unlike the more porous Russian material. Its color is a variety of green hues that will delight any person who works the malachite. This malachite will fit in any collection, rough or cut and polished.

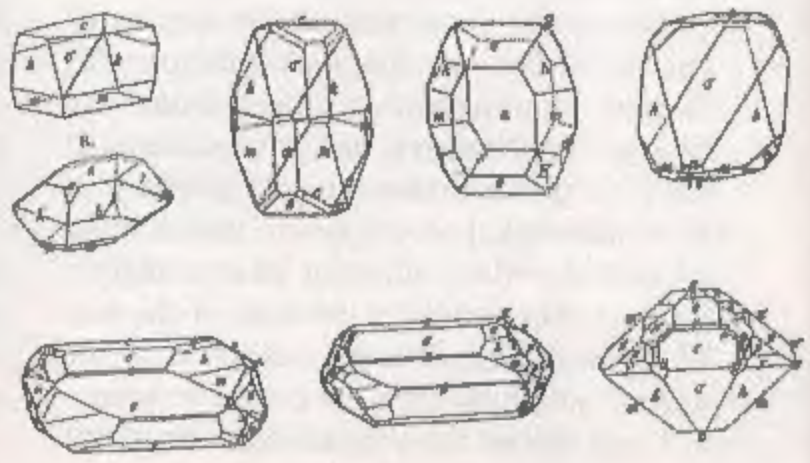
While Bisbee is well known for its great variety of azurite crystal habits, it is also just as well known among collectors for its superb malachite pseudomorphs. In addition, Bisbee also produced other forms of malachite: thick-banded gem crusts, sometimes alternating with gem-quality azurite layers, as well as stalactites. Normally, stalactites are composed of solid calcite. On rare occasions, solid, concentrically banded malachite stalactites were encountered. While large slices of these stalactites were once available, they are long gone now.

And while on the subject of stalactites, the long-running copper mine at Morenci produced quite a surprise a few years ago. Morenci was one of the first copper deposits worked in Arizona, and it is still being worked. A few years ago, mining cut into a remaining oxide zone full of carbonate copper minerals. Luckily, the mine owners had granted a specimen contract to a group. As miners cut into the oxide ore, they opened small pockets of azurite. More exciting, a large seam actually was cut into, and it was full of stunningly long "fingers" of matrix completely covered with tiny, bright, sharp azurite crystals. Many of these stalactites were an inch or more long, covered with azurite and jutting up from a matrix covered with similar bright blue crystals. The finest of these stalactites actually extended over 6 inches in length in very closely spaced clusters. The azurites themselves were not large, seldom exceeding ⅛ inch long. In spite of such small crystals, this stalactitic material was stunning in its natural beauty. While the larger cabinet specimens have long since been swept up by wealthy collectors, individual "fingers" of these azurites are still bandied about. Watch for them.

Another Arizona mine that has produced some interesting azurites and malachite pseudomorphs is the New Cornelia pit in Ajo, now closed. Its azurites seldom reached more than an inch, and just about every one I've ever seen had an internal core of malachite. Along with these bright, highly modified, monoclinic crystals were crystals of perfect monoclinic textbook form. What made these simple crystals interesting was that the crystals were completely altered to malachite, pseudomorphed from the original azurite. Most were found slightly embedded in matrix coated with velvety malachite. These Ajo azurite/malachite specimens are still available in limited amounts, so the Frugal Collector has a chance at getting one of these little beauties.

Azurite and malachite are often a readily available contrasting and colorful addition to the Frugal Collector's collection. Seldom have I looked at a dealer's stock and not seen a very nice specimen of these two lovely copper minerals for sale at a reasonable price.

As a collector, keep in mind that virtually all the world's upper oxide zone copper deposits, source of virtually all azurite and malachite, have been mined out. For the present, the exceptions are Central Africa and China. Common sense dictates these sources will, one day, be mined out. Needless to say, the collecting world will be the worse for it!



The crystal habit for malachite (left) is a rarity. These are just a few of the crystal habits seen in Arizona azurites (right).

SHOP TALK

by William A. Kappele

Working with Ironwood

Recently, a reader wrote in about an article on ironwood that I had written several years ago. The reader's concern was that I had not been clear on just what tools and techniques should be used in working with this material. Upon hearing this, I went back to the article ("Cabochons and More from Ironwood," December 1998 *Rock & Gem*) and checked it out. It seemed clear to me, but I realized that I had referred to woodworking tools, and I guess I assumed that all readers would be familiar with them.

As far as technique goes, making a cab of ironwood is exactly the same as making one of stone—but it's a lot quicker, and can be done with no power tools at all. Essentially, what I did was first to find a suitable piece of wood and cut a slab, just as I would with stone. I used a woodcutting band saw instead of my diamond saw, but any kind of handsaw would have done the job. Next, I cut a preform with the band saw, but again, a coping saw, which can be purchased at any hardware store or home center for a few dollars, would have done just fine.

From here on, although a power disk or belt sander would have worked, I did it all by hand. After filing the preform to final shape with a wood rasp, I selected a block of scrap wood and stuck the preform to it with double-sided carpet tape. The end of the block went into the vise, and I was ready to go. I used the wood rasp and worked around the preform, "peeling the apple" until I had the rough cabochon shape. Then, starting with #80 grit no-clog sandpaper, I worked down through #100 and #220. The final finish was done with #400 and #600 wet-or-dry paper, used dry. I used a power buffer to bring up the shine, but a coat of wax buffed out by hand would do an equally good job.

Now in the interest of science, and to see if readers could use their rock-cutting, -grinding, -sanding, and -polishing equipment on ironwood, I decided to give it a try. I dug a piece of rough out of my pile and took it to my old faithful rock saw. This veteran of everything from Utah sandstone to Montana agate revved up, took a bite, looked up at me, and said, "Are you kidding?" Diamond blades are made to knock little chunks off hard stone, not soft wood. Even though ironwood is hard by wood standards, it is Kleenex compared to agate. So much for sawing; just use the woodcutting handsaw.

The grinder was a little more promising. I tried my 180 grit disc, both wet and dry, with good results. The sawdust is a little messy, but so is rock dust. I went from the 180 grit wheel directly to the polishing pad. I used the same man-made polish I use on stones and tried it both dry and slightly wet. Dry worked fine, but was way too dusty. Wet worked much better. Both brought up a nice shine.

I guess the end result of all this is that if you just have to work with ironwood and have no other way to do it, you can use your lapidary equipment. I strongly recommend you use woodworking tools, though. I also suggest that, if you like incorporating wood into your lapidary hobby, you try a variety of woods. You don't need anything exotic, either. One of my favorites is the humble scrub oak limb. Just pick a desired size, slice off a slab, and make a cab, with the heartwood as a bull's-eye.

Finally, don't overlook using wood to teach kids how to make a cab. It is quick, cheap and safe, and will teach the basic technique while turning out a really nice cab.

Please feel free to contact me if you have a suggestion or comment about this or any of my Shop Talk columns. My e-mail is quappelle@cox.net, or write to me at 25231 Pericia Dr., Mission Viejo, CA 92691.

Collecting Fluorescent Minerals

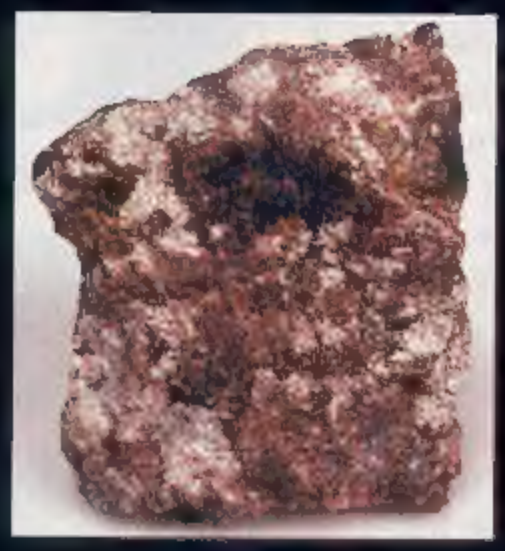
You Can Assemble a Top-Notch Collection

A mineral light is the fluorescent collector's only major expense. This was a popular portable SW/LW light for finding scheelite and uranium in the 1940s. (Photos by the author)

by Stuart Schneider

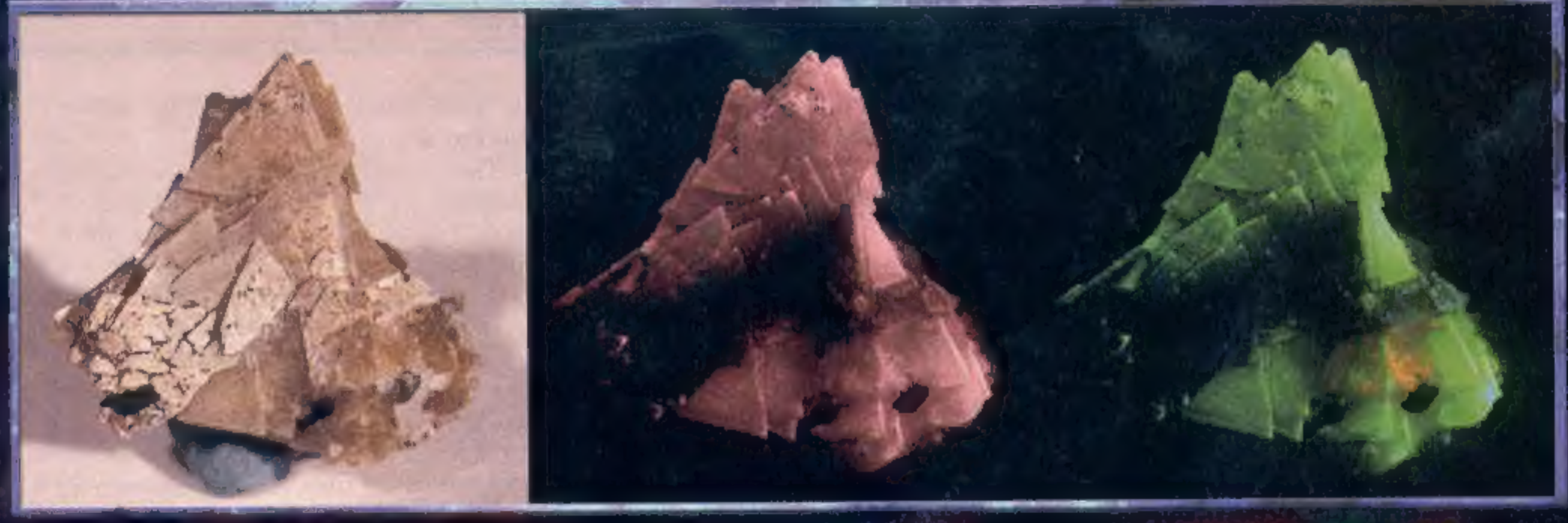
Everyone likes to look back and say that they were collecting—or wish they were collecting—a mineral in the old days when there were only a few collectors and the prices were reasonable. In those good old days, super pieces could be obtained that are virtually unobtainable today. In the field of fluorescent mineral collecting, we are still in the good old days, when you can put together a top-notch collection without spending much money. The best part is that great material is still available. The only exception to this bonanza for fluorescent collectors might be the rarest of the Franklin, New Jersey, fluorescents (this includes the Sterling Hill Mine in the adjoining town of Ogdensburg). The demand worldwide for the rarest and the best of the Franklin fluorescents outstrips the supply.

There is an incredibly active group of people who collect fluorescent minerals, and it seems that many mineral dealers are missing opportunities to supply this group. A quick look at the Fluorescent Mineral section of the Internet auction site eBay will expose you to hundreds of minerals that are available and the hundreds of collectors who actively visit that site. The number of fluorescent minerals offered and the number of fluorescent mineral collectors has grown larger each year. This boom in collecting has fortunately coincided with a strong supply of good fluorescent material becoming available. Most dealers at mineral shows know that fluorescent collectors are "out there," and yet so few can tell you which pieces on their table actually fluoresce. It may be just a matter of money or specialty. A dealer in $500+ minerals may not want to carry a $12 fluorescent or even a $200 fluorescent mineral about which he knows little.



A very rare Franklin, New Jersey, mineral, roeblingite glows red under SW ultraviolet, while xonotlite glows blue.

What are fluorescent minerals? There is a group of minerals that, when exposed to short-wave (SW), mid-wave (MW), or long-wave (LW) ultraviolet (UV) light, fluoresce or glow with extraordinary colors. Fluorescence is a physical process. In the process, light (electromagnetic radiation) of one wavelength strikes a fluorescent mineral and causes light to come out of that mineral at a longer wavelength. Once those wavelengths reach the visible spectrum, we



This specimen of Canadian genthelvite glows shades of green under SW and LW, and red under MW ultraviolet.

Calcite, fluorite and willemite from the Hogan Claim, near Wickenburg, Arizona, show up red/orange, blue, and phosphorescent green, respectively, under SW ultraviolet.

Clinohedrite (orange), hardystonite (purple/blue), and willemite (green) make a nice-looking rock under SW ultraviolet.

The barite in this specimen of barite on calcite from the Franklin Mine glows white under SW ultraviolet.

This sample of calcite (orange-red) and willemite (green) also contains crystals of franklinite and some zincite.

can see the different wavelengths as different colors. The colors can be spectacular. I like to think of my collection, when illuminated by UV light, as a miniature fireworks display without the problems of fire, noise, and regulations to distract me.

The discovery of fluorescence might be said to have begun with the mineral fluorite, from which the word "fluorescence" is derived. Not all fluorite fluoresces, but some of it really glows, and changes its color in bright sunlight. Around 1850, a scientist experimented with a piece of fluorite from England. It would exhibit a green color in the shade and a strong blue color in direct sunlight. He is credited with giving this ability to glow and change color under a different light source the name fluorescence.

The "standard" in fluorescent minerals is willemite and calcite from the Franklin, New Jersey, area. The towns of Franklin and Ogdensburg, located in the northern corner of the state, are known as the "Fluorescent Mineral Capital of the World." Often, the two towns' minerals are lumped together to become "Franklin minerals." Willemite and calcite from the old zinc mines in these two towns are two of the approximately 86 fluorescent minerals that can be found there. Sussex County, in which these two towns are located, is also home to about 375 other nonfluorescent minerals, so this area is a mecca for many mineral collectors. The willemites and calcites from Franklin glow a bright green and bright red-orange, respectively, when exposed to SW UV light. This brilliant day-glo response is brighter than that found in willemite or calcite from any other part of the world. A fluorescent mineral collector can easily identify Franklin-area rocks from those of other localities. When a person who is not familiar with fluorescent minerals first sees this effect, they can not help but ask if the rocks have been treated with some kind of special paint to make them glow that way. They may even ask if the rocks are radioactive. (They are not.)

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Collecting Fluorescent Minerals *from page 21*

Minerals that fluoresce generally do so because they contain an activator. In the case of Franklin material, the activators are usually manganese and/or lead. The opposite of an activator is a quencher. Iron is a known quencher of fluorescence. Most, but not all iron-containing minerals will not fluoresce. The zinc mines of Franklin contain very little iron in comparison to other zinc mines throughout the world. Barite, a fairly common collector's mineral, may or may not be fluorescent. Barites from Franklin and certain other places fluoresce a bright white, yellow or grey tan due to the activators. Most barites from other places do not fluoresce, since they do not contain the necessary activators.

Some stones fluoresce because they are radioactive and contain uranium family minerals. Geode interiors generally fluoresce due to small amounts of radioactive material. The study of fluorescence activators is vast, and entire chapters of books have been devoted to analyzing the subject.

As an interesting chapter in the history of analyzing activators, scientists in Princeton, New Jersey were fascinated by the fact that certain minerals would glow in different colors when struck by UV light. They created a group of synthetically activated minerals that would fluoresce in a specific color when hit with a focused beam of energy and applied this to the then new field of television. The science of fluorescent minerals is the reason we have color television today.

Scheelite, the source of the metal tungsten, fluoresces a bright blue-white without any known activators. The hunt for scheelite is responsible for the portable SW UV light. In the years leading up to World War II, much of our tungsten was made from Chinese scheelite. The government put out the word in the mining industry that scheelite was going to be more important than gold if the United States entered the war. Prospectors started looking for scheelite, but unfortunately, since it looks just like quartz, it was nearly impossible to recognize. A little known company, Ultra Violet Products (UVP), started by Thomas Warren, began to advise miners that scheelite glowed brightly under SW UV, and that UVP made portable UV lights that would enable miners to locate the ore. One miner, going over the tailings from an exhausted gold mine with his portable UV light, found that the tailings glowed bright blue-white and were full of scheelite. The old mine was sitting on a mountain of scheelite. The scheelite rush was on, and numerous discoveries were made in gold mines thought to be totally worked out.

The United States had its source of tungsten by the time the war started. Tom Warren's company became profitable and continued to improve the SW UV lights. As the lights became more available, collectors bought lights, joined together, and eventually formed the Fluorescent Mineral Society, a worldwide organization.

There is a similar story involving the 1950s uranium rush. As the United States began working on nuclear energy, miners went out to search for uranium ore. The Geiger counter was the tool of choice, but once a miner entered a mine with uranium-bearing minerals, the Geiger counter was overwhelmed by the radiation and could not pinpoint the source. UV lights were brought in and shined on the walls of the mine. The uranium ore glowed green. The UV light became an important tool in the arsenal of the uranium miner's equipment.

MINERAL LIGHTS

As you can see, the collecting of fluorescent minerals is not a very old hobby. Although a study of fluorescent minerals was done in 1903, it was not until the 1920s that a way was discovered to apply the information to the mining industry. Sparks in the Franklin Zinc Mine's machinery caused certain rocks to glow green or red. Geologists at the mine created an electric arc machine that gave off a similar spark, which contained substantial SW UV light. The green glowing rocks were willemite, a zinc ore mineral, while the red glowing rocks were mostly calcite, a non-ore bearing rock. The picking table, formerly used to pick out the wood and metal pieces that could damage the crushing machines, was now located under a spark machine that caused the rocks to glow. This enabled the mine to increase the zinc yield of ore going to the crusher. Eventually, these spark machines led to the portable SW UV lights that we know today.

Mineral lights are a fluorescent collector's first – and maybe the only – major expense. Without the proper light, the rocks will not glow. The lights are expensive. The biggest cost of the light is the SW filters, which are expensive pieces of coated quartz that must be able to pass only the proper frequencies (waves) of light. SW UV light is almost completely stopped by glass or plastic, so quartz glass must be used for the bulb and the filter. The UV light emitted by SW lamps is invisible, but the light also emits a wavelength of visible light. The quartz filter allows the UV light to pass

through but holds back most of the visible light.

Mineral lights are available in three wavelengths: LW, SW and MW, sometimes labeled as UVC, UVB and UVA, respectively. More minerals will fluoresce under SW than under LW. MW is a bit of a luxury for the advanced collector and probably unnecessary for the average collector. The advantage of MW is that certain minerals will show a different color response under MW than they show under SW or LW.

SW lights give out light in the 254 nanometer range. Nanometers are a measure of the length of the light wave. LW is produced in the 360 nanometer range, and MW is produced in the 302 nanometer range. Some minerals will glow strongly under one and not at all under the other. Some, such as calcite from Terlingua, Texas, will glow blue under SW and pink under LW. A beginning collector or mineral dealer probably should invest in a combination LW/SW UV light to cover most situations.

The black light that is widely sold in party stores and that lights up fluorescent paints and posters so nicely will not bring out the colors in most fluorescent minerals since it also passes a great deal of visible light. You need a specially filtered mineral light to obtain the best results.

A search of the Internet keywords mineral lights, a visit to my Web site's Fluorescent Mineral Museum resource page (www.worldofstones.com) or the advertisers in this magazine will give you a few good sources for these lights. Beware of the claims of "unfiltered" mineral lights that appear on eBay every few weeks. These lights are no better than black light party lights. Mineral lights cost anywhere from $30 to $400 or more. The cost difference is in the power of the light and the size of the filter. The lower end UV mineral lights are 4 watts or less and have a small filter. The higher end lights are 12 watts and higher and have a larger filter. I have used lights of several different powers over the years, and have found that, although expensive, the higher powered lights with the largest filters make looking at fluorescent minerals much more enjoyable. They bring out the best of the strong colors and bring out the weaker colors that may not show under a less powerful light. They also light up a larger area from farther away.

WHAT TO COLLECT

Certain locations are known for their fluorescent minerals. The first location is the Franklin area. The 86 or so fluorescent minerals there contain some of the brightest glowing material in the world, and many are unique to the Franklin area. Some of the classics, besides willemite and calcite, are hardystonite (purple-blue SW), clinohedrite (pumpkin orange SW), esperite (bright lemon yellow SW), margarosanite (pink or sky blue SW), hydrozincite (bright blue white SW), fluorapatite (orange SW), sphalerite (blue or orange LW), and prehnite (pink or peach SW).

Another place for great fluorescents is Mount Saint Hilaire in Quebec. About 45 fluorescent minerals, including agrellite (purple pink SW), genthelvite (green SW, peach MW), sodalite (orange LW), and hackmanite (orange LW), are found there. Arizona has a nice group of fluorescents such as fluorite, willemite, calcite and a group of uranium activated minerals. Each of the different states in the United States can claim a few fluorescents, such as manganapatite from New Hampshire or Maine (yellow-orange SW), scheelite from Connecticut, Arizona or California (blue white SW), Terlingua calcite from Texas (blue SW and pink LW), eucryptite from New Hampshire (cherry red SW), benitoite from California (bright blue SW), fluorite from Illinois or Ohio (cream white LW), and magnesite from Pennsylvania (blue-white SW and LW).

Other countries' mines produce great fluorescents, such as svabite from Sweden (bright orange SW), apatite from Pakistan (yellow SW), baratovite from Tajikistan (sky blue SW), selenite roses from British Columbia (gray tan SW and LW, and highly phosphorescent), sodalite and tugtupite from Greenland (orange LW and cherry red SW, respectively), fluorites from Weardale, England (bright purple LW), rubies from India (cherry red LW), diamonds from Africa (tan or blue white SW), and scheelite crystals from China (bright blue white SW).

Some of the colors are bright. Other colors are muted. A single stone may have two shades of calcite. (In Franklin, the closer to the ore body, usually, the brighter the color.) Prices vary from $1 a pound to $1,000 per ounce.

Collectors seek stones that have several fluorescent minerals on one stone. A Franklin stone containing esperite and willemite will glow yellow and green. Add in some purple blue fluorescing hardystonite, pumpkin-orange clinohedrite, and red orange fluorescing calcite, and you have a symphony of color. Needless to say, the more colors on a stone, the more valuable the stone.

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Collecting Fluorescent Minerals *from page 23*

WHERE TO COLLECT

A good place to start is eBay. Enough fluorescent minerals are available at any given time to give you a good idea of where the market is on that particular stone. A Google search of fluorescent minerals will turn up dealers and a few mines that sell material to collectors. Last year I attended the Tucson Gem & Mineral Show and found a substantial quantity of material available from the dealers. Many had set up fluorescent viewing areas in their bathrooms. Dealers from Pakistan, China and Russia had interesting material that rarely shows up at local rock and gem shows.

Depending upon what you want to collect, a trip to a mine or mine dump can be a collection enhancing experience. The Franklin Mine closed up in 1954, but the museum is now open and the mine dump is available for fee collecting. The Sterling Hill Mine closed in 1986, but due to the dedication of brothers Richard and Robert Hauck and a cadre of mine enthusiasts, mine tours are available, the Thomas Warren Museum of Fluorescent Minerals can be visited, and the mine dump is open on the last Sunday of each month for fee-collecting.

Old mines in every state can contain a mine dump where the unwanted material was dumped. Occasionally, road cuts and new house construction in the mining vicinity will expose a new source of material. Checking these areas with a SW or LW UV light at night can be an exciting and rewarding experience. Once you get a basic knowledge of fluorescent minerals under your belt, you can take your light to gem and mineral shows and check the dealers' stock.

LAPIDARY WORK WITH FLUORESCENTS

Many of the Franklin fluorescents are assemblages of interesting minerals under daylight as well as UV light. You can saw slabs and polish cabochons out of many of these rocks. Several fluorescent minerals are also gemstones. Tugtupite can a beautiful cherry red stone that polishes up into beautiful and expensive cabochons. Benitoite, at its best, is a beauty when faceted. The stones resemble blue tanzanite. There is a small quantity of gem willemite crystals that have been faceted. Fluorapatite crystals can be polished or faceted. The downside of polishing fluorescents is that they tend to be a bit softer and can chip or break if worked too hard or dropped. When agates and jaspers get a bit too common, though, you may want to try your hand at polishing fluorescent minerals.

RADIOACTIVE MINERAL COLLECTING

If you have a hankering for radioactive minerals that fluoresce, you might look for autunite, torbernite, carnotite, uraninite, monazite, pitchblende and other uranium ore minerals for your collection. When dealing with radioactive minerals, a few rules must be obeyed.

1. Store them in an airtight container. They produce radioactive gas (radon) and dust that can get into the air and onto your skin or clothing. The dust should not be inhaled. If you accumulate numerous specimens they should be kept in lead containers.

2. Keep your specimens away from places occupied by people (such as kitchens, bedrooms, etc.) and away from children.

3. Make sure that they are labeled "Radioactive." Clean up flakes and broken pieces that might work their way into clothes, food, lungs, etc. Your LW UV light will help you find the particles.

There is no reason why a group of radioactive fluorescents can not be an interesting addition to your fluorescent collection as long as you take the appropriate precautions.

It is possible to tumble some fluorescents, but many of the Franklin minerals have combinations of andradite, willemite and calcite in one stone. When tumbled, the harder parts of the rock scratch the softer parts and the resulting tumbled stones will never have the high shine of jaspers and agates.

As with any collectible, the more you know, the easier it is to find and recognize good material. This article can give you a start, but there are a few good books on fluorescent minerals that you should read as references. If your interest is more than just passing, consider joining the Fluorescent Mineral Society (www.uvminerals.org) or the Franklin/Ogdensburg Mineral Society. Each publishes a journal, hosts speakers at its meetings, and contains knowledgeable members worldwide.

Stuart Schneider is the author of Collecting Fluorescent Minerals, *which is expected to be published in 2004 by Schiffer Publishing of Atglen, Pennsylvania.*

LAPIDARY LORE and MORE

by June Culp Zeitner

The Fabulous '50s

Sand calcite crystals from Rattlesnake Butte, South Dakota, are unique.

Besides the first Tucson show, now the world's largest and best, what else do the 1950s offer to the history of our hobby? Plenty! It was a major decade of growth in all ways: new discoveries, important books, many new clubs, lapidary improvements, bigger and better shows, and new inventions and techniques. This was the decade when many of us tried to make our own lumbyers, or improve on the polish of our stones, or cut down on the time or the noise. This is the decade when faceting became easier and more popular, with new machines and new cuts on the increase.

Important books were published in the '50s. There was a rash of *Gem Trails* books, including my *Midwest Gem Trails*, still in publication after many complete revisions. Other guides were published about the Northwest, Oregon, Washington, California, Arizona, Texas, Colorado, Nevada, and Idaho. Other useful small books included Dake's *The Agate Book* and Ransom's *Petrified Forest Gem Trails*. To me, the most important was *Gemstones of North America* by John Sinkankas, published in 1959. How I wish it had been published in 1949 instead, so that Albert and I could have used all the wonderful information in the first decade of our 30 years of travel.

Popular Gemology, by Richard Pearl, and *Getting Acquainted with Minerals* by English and Jensen, were written for new hobbyists. (Richard Pearl and David Jensen were my friends.) For lapidaries, Parsons and Soukup wrote *Gem Materials Data Book*. For fossil collectors, there was Casanova's *An Illustrated Guide to Fossil Collecting*.

We saw our first big show in Oakland, California, in 1951. What a thrill it lured us to attend our first national show at Tacoma, Washington, the next year. From then on, we seldom missed a National AMFS show as long as we were traveling full-time. We first saw the stunning O.C. Barnes 63-piece onyx dinnerware set, the elegant Paul Broste sphere collection, and the gorgeous George Ashley gem bowls at shows in the '50s.

Joe Phetteplace's huge gem intarsia "Man O' War" was a show star starting in 1956. Thomas Warren created great interest in fluorescent minerals in the '50s. As president of the UltraViolet Products Co., he attended many shows. His exhibits were often the most crowded part of shows from coast to coast. We met Mr. Warren at a Tucson show, and resolved to get a fluorescent display for our family museum in Mission, South Dakota. He even took time to give us some pointers.

Arguably our best-known gem sculptor, Dona Hord finished his famous statue "Morning," a waking American Indian, carved from a 3-ton block of California diorite, in the '50s. Dona was known worldwide for his large, stirring sculptures.

Many great discoveries were made during the '50s. A significant one for our hobby was the discovery by General Electric of how to manufacture diamond. Russia started mining its diamond fields in the mid '50s, though it had been more than a century since Humboldt reported that Siberian peasants were paying their taxes in small diamonds. New opal fields were found in Australia at Andamooka and Coober Pedy. John Sinkankas participated in the biggest California tourmaline strike in 42 years. The record find was at Mesa Grande in 1958.

More good field trip areas were open to us than previously, probably because Oregon and California chambers of commerce became aware of the rockhounding hobby, ranchers and mine owners had not become tired of our pleas to "just take a look at those rocks over there" and the government hadn't decided to turn public lands into roadless wildernesses.

When Albert and I started our long, long trip in 1950, people gladly told us about any rocks or minerals in their area. We got permission everywhere we asked, and more often than not, we were invited to park in the yard overnight, or at least stay for dinner.

Our first stop after leaving South Dakota was at Little Falls, Minnesota. It was a three-day stop forced by several flat tires on our new, but overloaded, trailer. We asked around, and an old lady volunteered that as a child she and her classmates used to find pretty, little, cross-shaped, reddish stones for their slingshots. We went to the creek she described, waded in, and pulled out handfuls of staurolites, which to my delight looked just like the textbook pictures.

Since the '50s were the most influential years of my life on the rocks, a few highlights of the mineral kingdom's most notable states at that time will show what field trips were like in those truly "good old days!"

Maine. Pink and watermelon tourmaline, lepidolite, apatite, quartz (rose), cleavelandite, and spodumene were found, mostly on Mount Mica and Mount Apatite. Directions and permission were given by our friend Stanley Perham, now deceased.

New Jersey. Franklin Furnace was the name on the map at that time. Head geologist Bauer showed us where to find the best fluorescents, showed us what they looked like, and approved of our finds, which included calcite, zincite, franklinite, and even some sphalerite and rhodonite specimens for a bright display, and a little lapidary material, too.

North Carolina. It was a paradise for collectors in the '50s, with lots of rock shops, many miners, and plenty of residents, all glad to help. We loved the Southern food, including grits. In our treasure box to ship home was actinolite, muscovite, beryl, quartz, spodumene, epidote,

kyanite rutile, thulite rhodolite amethyst, staurolite, and unakite. We later spent a whole summer near Great Smoky Mountains National Park while I was working on *Appalachian Mineral and Gem Trails*.

Arizona. Upon arrival, we heard that if we once saw Arizona's deserts in the spring, we would return. Return from where? We didn't even want to leave! Of course, we visited Bisbee and went into the Copper Queen Mine. What glory! The ceiling glittering with diamondlike clear calcite crystals and turquoise colored aurichalcite, the walls green and blue with malachite and azurite. Aladdin's cave indeed, except for the sound of blasting up above. After collecting there, we saw two vibrant collections of Bisbee material, one at a bank and one at a barbershop. In Phoenix, we met Dr. Arthur Flagg. What a great man. He told us all about hunting in the mine dumps and abandoned prospects on the desert and showed us samples of what we might find. He said he would be glad to identify anything we were puzzled about. He invited us to the Arizona Mineralogical Society, and several members became friends and guides. We found rosasite, chromebastite, bornite, chalcopyrite, tenorite, linarite, and native copper, to name a few. We spent seven winters in Arizona, and I go to Tucson for a week every February.

South Dakota. We always came home to South Dakota for a short time each summer. The badlands and Black Hills had so many wonderful places to collect. Some of the specimens, like the sand calcite crystals and the newly discovered golden barite, were excellent trading stock. (We actually traded a nice sand calcite for a fine specimen of benitoite with neptunite.) Other South Dakota minerals and gems were plentiful and access was no problem. We found cassiterite, columbite, tantalite, schorl, beryl, spodumene, almandine, apatite, microcline, arsenopyrite, and much more. Sometimes, we even found a little gold. Our mentor and frequent companion was Willard Roberts, one of America's leading mineralogists.

As for lapidary material, it was hard to miss. My sister once found a showy Fairburn agate within the city limits of Rapid City. While Albert was in the hospital, if he was sleeping, I'd go outside and look for chalcedony, carnelian agate, jasper, and other quartz materials in the Cheyenne River gravel that was used in the landscaping. The badlands, with countless lapidary treasures, start only a few miles southeast of Rapid City. Now, a government bureaucracy proposes to turn most of this National Grassland area into a roadless wilderness, where the old, the handicapped, and most of the young can never collect again. And that is only one of the reasons field trips like those of the '50s cannot occur now or in the future.

Successful Diamond Drilling

Get the Most from Your Drilling Operation

by Brian Farberov

The diamond drill itself is only a small factor in your drilling operation. Successful diamond drilling is both an art and science that can be mastered with proper understanding of how to use drilling speed and pressure, coolants and drilling accessories, and select the right diamond drill for your material. While this understanding is best gained through experience, even new diamond drill users can quickly become proficient by learning and applying some basic principles of diamond drilling.

The following recommendations have come from years of experience in research, development and manufacturing of precision diamond products, as well as years of personal experience and observation. Following these drilling suggestions will help you drill faster and easier, obtain a smoother surface finish, minimize damage to your material, and extend the life of your diamond drill.

Before Drilling

Before beginning your drilling operation, visually examine the drill for cracks or other damage, as well as for run out. Run out will cause excess vibration when you are drilling and affect the circumference (roundness) of your hole. Instead of being perfectly round, your hole will become elliptical and uneven. Drill run out will also affect the tolerances you are able to achieve. To check for run out, use an indicator specifically designed for this purpose. Bring the indicator close to the drill, until its spring just touches the surface of the drill. The dial of the indicator should indicate 0. Turn on your drilling machine, holding the indicator firmly in place. The dial of your indicator should remain at 0 while your drill is running (rotating). This means you have no drill run out. If your indicator reading is greater than 0, your drill is running out. Turn off your drilling machine and remount the drill.

Successful diamond drilling requires experience and an understanding of the equipment. (Photos courtesy D'KAM Industrial Superhard Tools)

A black marker is an alternative if you have don't have a run out indicator available. Take a piece of paper, or any thin piece of material, and measure its thickness using a caliper or micrometer. Place the material firmly against the drill. Holding the marker firmly in place, remove the material between the drill and the marker. Turn on your drilling machine, and observe the drill rotation. If the marker touches surface of the drill, there is too much drill run out. Turn off the drilling machine, and try again.

Another effective way of checking drill run out is to rotate the drill head assembly (including the water swivel adapter, if your drill has this feature) by hand. The run out of the drill diamond section (the cutting/drilling edge) will be indicated by the stem. Wobble the head of the water swivel adapter using your hand. If too much vibration exists, your drill will run out.

A strong correlation exists between the run out on the water swivel adapter and on the diamond drill; the larger the run out on the water swivel adapter, the larger the run out will be on the drill. If the run out is not properly indicated, the drilling operation will not be accurate.

You should also ensure that your drilling accessories are properly held in the chuck. If the drill or drilling device is not running true, loosen the chuck of your drilling machine, turn it 90 degrees and run your drill again. If this does not work, examine the condition of your equipment. Mount the drill on another drilling machine. Make sure your drilling equipment is in the proper condition to accomplish your objectives. No matter how well the diamond drill is made, it will not give you close tolerances if the shaft, or chuck, of your drilling equipment is misaligned or vibrates.

Always wear the proper safety equipment, including safety footwear, snug-fitting cloth

Diamond drills must be periodically dressed to expose new diamands.

All diamond drills must be used with coolant, such as water, water-soluble coolants, or mineral oils.

ing, safety goggles, hearing and head protection, and proper respiratory equipment, and do not use your drill if you suspect it is damaged. Damaged, incorrectly mounted, or misused drills can be very dangerous.

Starting a Hole

Once you have made sure that your drill is in good condition, you are ready to start your drilling operation. Clearly mark the insertion point on the material to be drilled and line the drill up to this point. Drill by quickly pressing and lifting the drill head. Moving the drill up and down frequently during the drilling operation will allow the coolant to cool the drill and flush out the material debris formed while drilling. The color of the water in the drilling zone should be milky white.

Be careful not to use excessive pressure while drilling. If material debris becomes stuck inside the drill, flush it out with coolant before continuing the drilling operation.

It is also extremely important that the material or part you are drilling be held firmly in place with a clamp throughout the drilling operation. Any material movement can cause the diamond section of the drill to break, possibly resulting in material damage or operator injury. For drilling thinner materials and substrates, consider using heavy-duty double sided tape to firmly hold your material in place.

Drilling Speed and Pressure

To maximize the life of your drill and minimize material damage, it is important to run your drills at the proper drill speed and pressure. Drilling speeds vary with the diameter of the diamond drill, diamond mesh size, the coolant being used, drill wall thickness, diamond bond type and hardness, as well as material hardness. Micro Diamond Drills from .001 inch require drilling speeds of 150,000+ rpm, whereas very large diamond drills (48 inches in diameter) require drilling speeds as low as 3 rpm.

Soft, abrasive materials can typically handle higher drilling speeds, while hard, dense materials require much slower speeds. Since diamond drills are primarily used in hard material applications, they are typically used at very slow speeds. Make sure your drilling equipment can run at the recommended speeds set for your diamond drills. Faster drilling might appear to increase your production efficiency, but the tradeoff is a significant increase in friction and heat, which considerably reduces drill life and increases the risk of heat fractures and breakage in the material being drilled.

There are dozens of types of lapidary diamond drills, including sintered (metal bond), hybrid bond, and electroplated drills.

It is also very important to apply the right amount of pressure during drilling. Use light to medium pressure, gradually feeding the drill into the material until the drilling begins to progress at its own speed. Increasing pressure on the drill will do little to reduce the time it takes you to complete a hole, but it will cause your drill to overload and overheat, which will lead to excessive wear on the drill and defects in the material being drilled.

When you are drilling completely through a piece of material and the hole is near completion, reduce the drill pressure considerably to minimize chipping of the material. Never force a diamond drill. Apply even pressure until the drill and material just touch. Since the drill and material surface are not perfectly even (symmetric) to each other, this lets the drill surface become sharper and adjust to the surface of material.

If a diamond core drill develops dark "burn" marks at the diamond section, the drill speed is probably too high or the amount of pressure is too great. Reduce the drilling speed or pressure accordingly.

Coolant

The most frequent cause of diamond drill damage is drilling without enough coolant. Never run a diamond drill dry, coolant should always be used to cool and lubricate the drill and to flush out abrasive particles formed while drilling. Water is the most frequently used coolant because it typically provides excellent performance at a minimal cost. Water is a true organic coolant, which does not leave the material being machined oily, greasy or contaminated. Other types of coolant include synthetic water-soluble coolants, mineral oils, other oils, and air.

If you are planning to use water as a coolant, check with the drill manufacturer to find out what water pressure is required and whether any additives are recommended. (Note that using additives will require a circulating system to ensure that the right ratio is maintained between your additive and coolant.)

continued on next page

The coolant must also be applied in the right place to ensure that it properly cools the drill and the material being drilled. The coolant should be directed so that the full flow is at the point of contact between the drill and the material, and facing the same direction as the rotation of the drill.

When drilling on a vertical surface (not recommended for lapidary materials), use a squirt bottle or small cup of water to continuously pour water onto the drilling zone. Make sure enough coolant is reaching the drill. Alternatively, you can submerge the material in a shallow tub of coolant so that the coolant just barely covers the material surface. If coolants cannot be used, consider using air to cool your diamond drills. If air cannot be used, a resin bond or electroplated (nickel bonded) diamond drill may be a solution.

Using Proper Drilling Accessories

Most diamond drills used in the lapidary industry are on a vertical surface, with coolant running through the center of the drill. If your current drilling equipment does not provide coolant centered capabilities, consider using a water swivel adapter. These devices provide a constant, controllable flow of coolant through the center of the drill and are designed to efficiently and effectively cool both the drill and the material in the drilling zone. Water swivel adapters, also known as drill head assemblies, can help increase the life of your diamond drill by 40 to 75 percent on average. Running coolant through center of your drills is the best method when drilling very hard materials such as lapidary materials. Doing so will help you improve material surface finish and prevent many micro cracks, which are associated with material overheating during drilling. UKAM Industrial Superhard Tools manufactures water swivel adapters to fit just about any drilling equipment. When considering using a water swivel adapter, make sure it is designed to be used at the rpm at which you are planning to run your drills. Water swivel adapters that are made from stainless steel and ball bearings, and with adjustable water flow, are preferable over water swivel adapters made from brass and no bearings.

Water swivel adapters are generally used with sintered (metal bond) diamond drills or hybrid bond diamond drills that are mounted on a collet with female thread. Water swivel adapters are designed to fit all standard diamond drills with 5/8-11 inch thread, other thread sizes are available, too. Diamond solid drills and most electroplated (nickel bond) diamond drills are usually made with a straight shank and are not designed for coolant to run through center of drill. They should be used submerged with coolant.

No matter what type of diamond drill or coolant applicator is used, the amount of coolant used should increase with the hardness of the material being drilled. Sparks during the drilling operation indicate that insufficient coolant is reaching the drilling zone or that the type of coolant being used is ineffective for that application. A generous flow of coolant increases the diamond drill efficiency and reduces heat buildup, thereby reducing the material cracks and deformation associated with overheating.

Strong coolant pressure will also wash out any material debris (center plugs) that becomes stuck in center of your drill. Center plugs restrict coolant flow to the center of the drill and prevent coolant from reaching the diamond section. As a result, your drill will start to drill dry, significantly reducing the drill life and material surface finish and deteriorating the overall drilling operation. Center plugs are behind 90 percent of all drill wreckage.

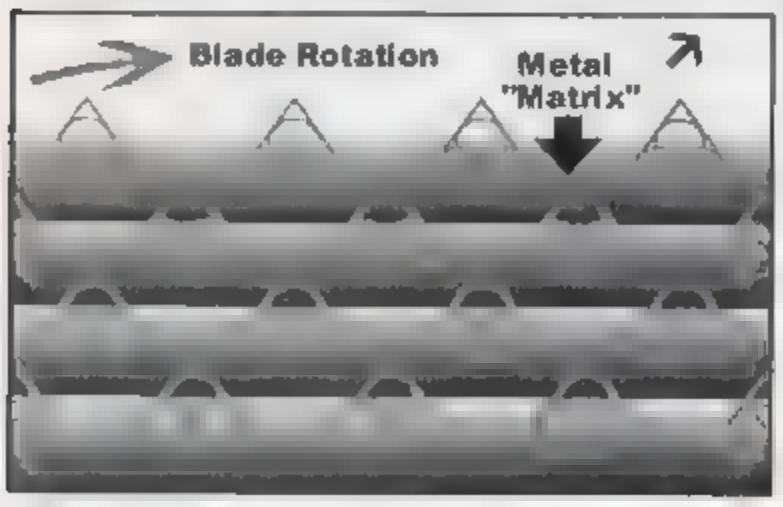
Drilling speeds are affected by the hardness and abrasiveness of the material, the age and condition of the equipment, and the amount of pressure and coolant used. The only real way to develop the right drilling process for a given application is through experience. If you are new to diamond drilling, you should start at low speeds and low pressure with large amounts of coolant to minimize the risk of drill and material damage until you can build your experience using a specific diamond drill, setup, and application.

Drilling Depth

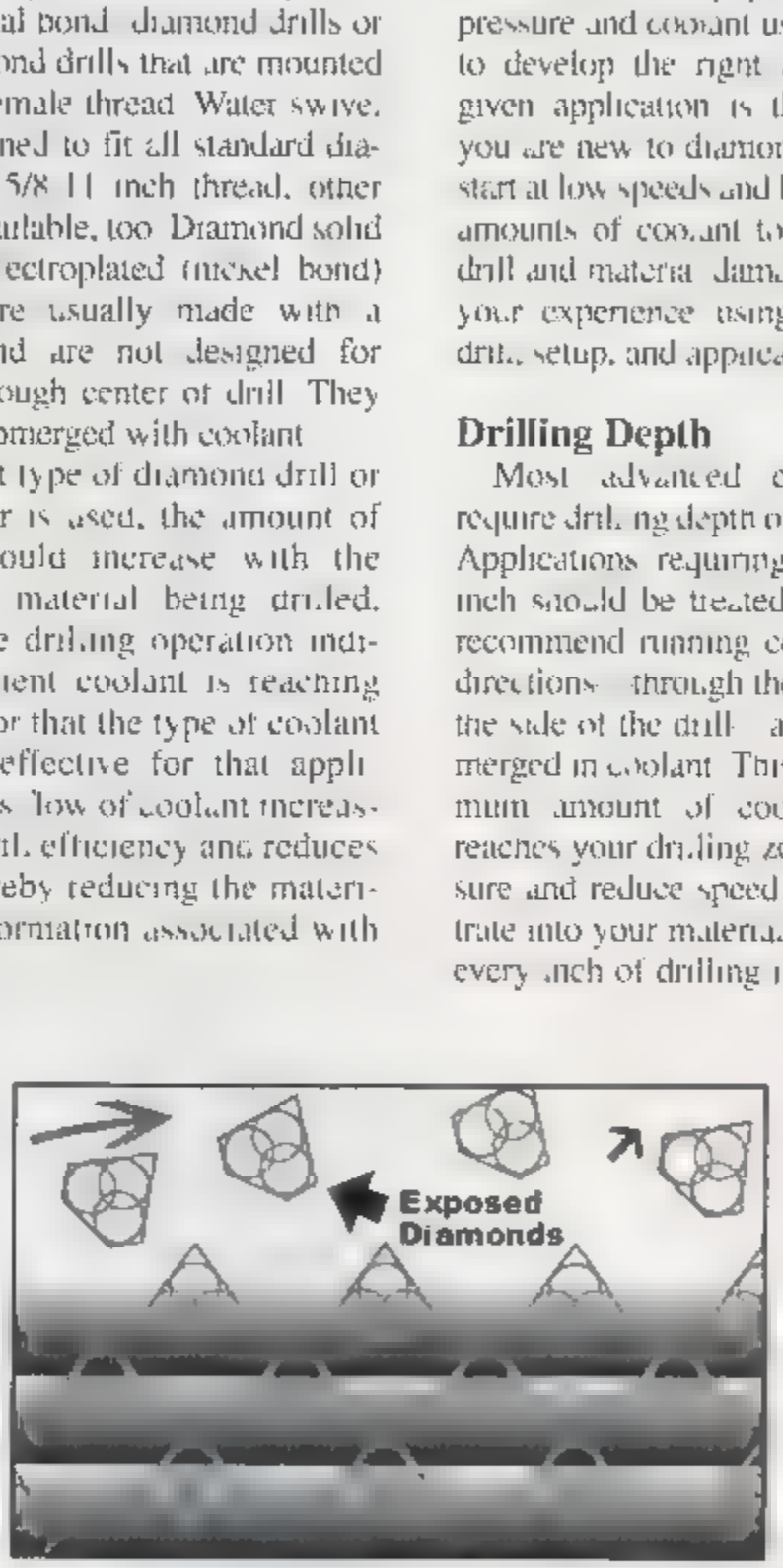
Most advanced ceramic applications require drilling depth of not more than 1 inch. Applications requiring you to drill over 1 inch should be treated in a different way. I recommend running coolants from multiple directions – through the drill center and from the side of the drill – as well as drilling submerged in coolant. This will insure the maximum amount of coolant and lubrication reaches your drilling zone. Apply more pressure and reduce speed the deeper you penetrate into your material. Lift the drill up after every inch of drilling into your material, let

How Smart Cut Works

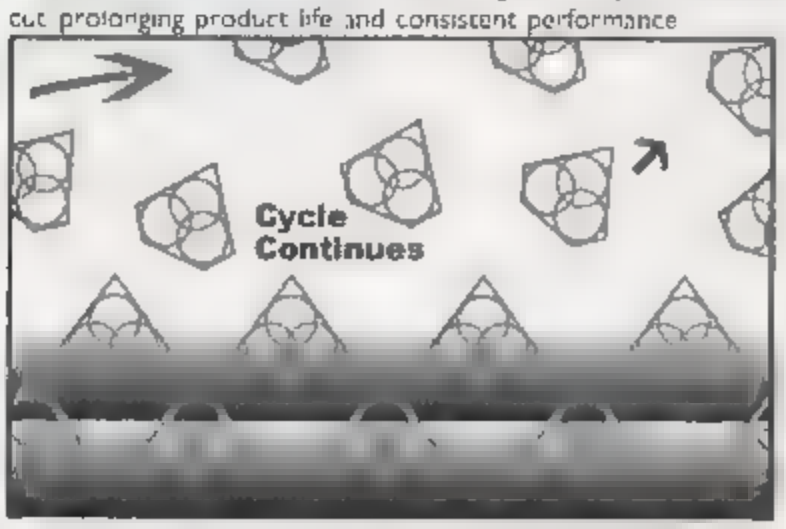
The sharpest and finest quality DeBeers diamonds that go into a Smart Cut Diamond Bond immediately penetrate into the material, grinding and polishing as they cut.



Diamonds are activated only at the exposed layer. As diamond layers begin to wear out, diamonds in a new diamond layer are immediately activated, substituting the already used up diamond layer. The Smart Cut Diamond Bond makes sure every diamond is in the right place at the right time, working where you need it most.



The newly exposed diamonds don't affect diamonds already working on the material. Unlike many other diamond bonds, diamonds in a Smart Cut remain sharp and grow sharper with each cut, prolonging product life and consistent performance.



This advanced formulated open diamond bond design ensures minimal chipping, fast cut, constant speed of cut, minimal cutting noise, and most important of all, minimal loss of precious material.

ing the drill cool and letting coolant reach deeper into your hole. Carefully examine the diamond tip condition, making sure it's round and not overheated.

Your maximum drilling depth will also be limited by spindle travel, the distance your drilling equipment can move in an upward and downward motion before touching the surface of your material. Be sure to take this into consideration when ordering diamond drills.

Dressing Diamond Drills

Most diamond drills can be dressed (re-trued) several times to extend their useful life. Never assume that because your diamond is new it does not require this operation. The wear on the diamond drill depth usually takes place on the drill core and diamond section, as well as on the wall thickness. A diamond drill can be dressed using a dressing stick or a used silicon carbide wheel to the point where the wall thickness is standard.

While dressing can improve the drill's accuracy, it can also cause diamonds to be pulled out from the drill diamond section (diamond tip). You can re-expose the diamond section by drilling into an Al_2O_3 stick a few times after the dressing operation.

Small-Diameter Drills

Small diameter diamond drills must be used at significantly higher speeds than larger size drills. It has been found that higher revolutions per minute (rpm) improve surface finish and overall drilling performance. Correct rpm for diamond solid drills (.01 inch to 2.5 mm, without a center hole for coolant flow capabilities) range from 9,000 to 450,000. Drilling equipment that can accommodate these speeds include high speed air spindles, hand-held drills, and other specialty micro drilling equipment. High-speed air spindles can run up to 450,000 rpm, hand-held drilling machines to 35,000 rpm, and specialty micro drilling equipment up to 25,000 rpm. All diamond solid drills and diamond micro drills must be used with coolant. I recommend either drilling submerged in coolant or applying oil as coolant (in some cases) if other liquid coolant types cannot be used.

Smaller size diamond core drills (.6 mm to .1 inch) mounted on a collet with thread and designed to run coolant through the center of the drill) must run with high coolant pressure (45 psi) through the center of the drill. This is the key to successfully drilling very hard materials. Drilling submerged in coolant is not recommended. Once the core (material debris) becomes stuck inside the drill, coolant is blocked off from the drilling zone, and the drill can no longer be used.

It is very important that you periodically check the inside of the drill for material clog up. If you spot the material core becoming clogged up, flush out this debris using coolant pressure from a water swivel adapter or other coolant source. Continue drilling only after the debris has been removed.

Proper diamond drill care and maintenance is very important for optimum drilling performance. Maintaining the diamond section shape and rigidity is important to prevent the drill from losing its sharpness and roundness. Make sure to repeatedly dress and retrue the drill's diamond section to re-expose new diamonds. If you see the diamond drill has lost its shape or rigidity, send it back to the manufacturer to be retrued.

Evaluating Performance

There are various criteria for evaluating diamond drill performance. The importance of each variable will depend on your requirements. Diamond drill life, an important variable for many high production drilling operations, can be determined by the number of holes a drill can produce. Drill life is affected by various factors, such as the material being drilled, bond type, the coolant used, the drill manufacturer, operator experience, the age and condition of the drilling equipment, etc. You may find estimating diamond drill life a fairly difficult process. Precision tolerances and surface finish quality also remain important considerations for drilling lapidary materials. In this case, drilling performance is evaluated by the amount of chips generated on the face of material. A visual check is just about the only way of checking finish quality. Another factor you want to consider is diamond drill break-in time and frequency of dressing. All diamond drills require time to break in, to produce relatively chip free performance. The period of time under which this occurs separates one diamond drill from another.

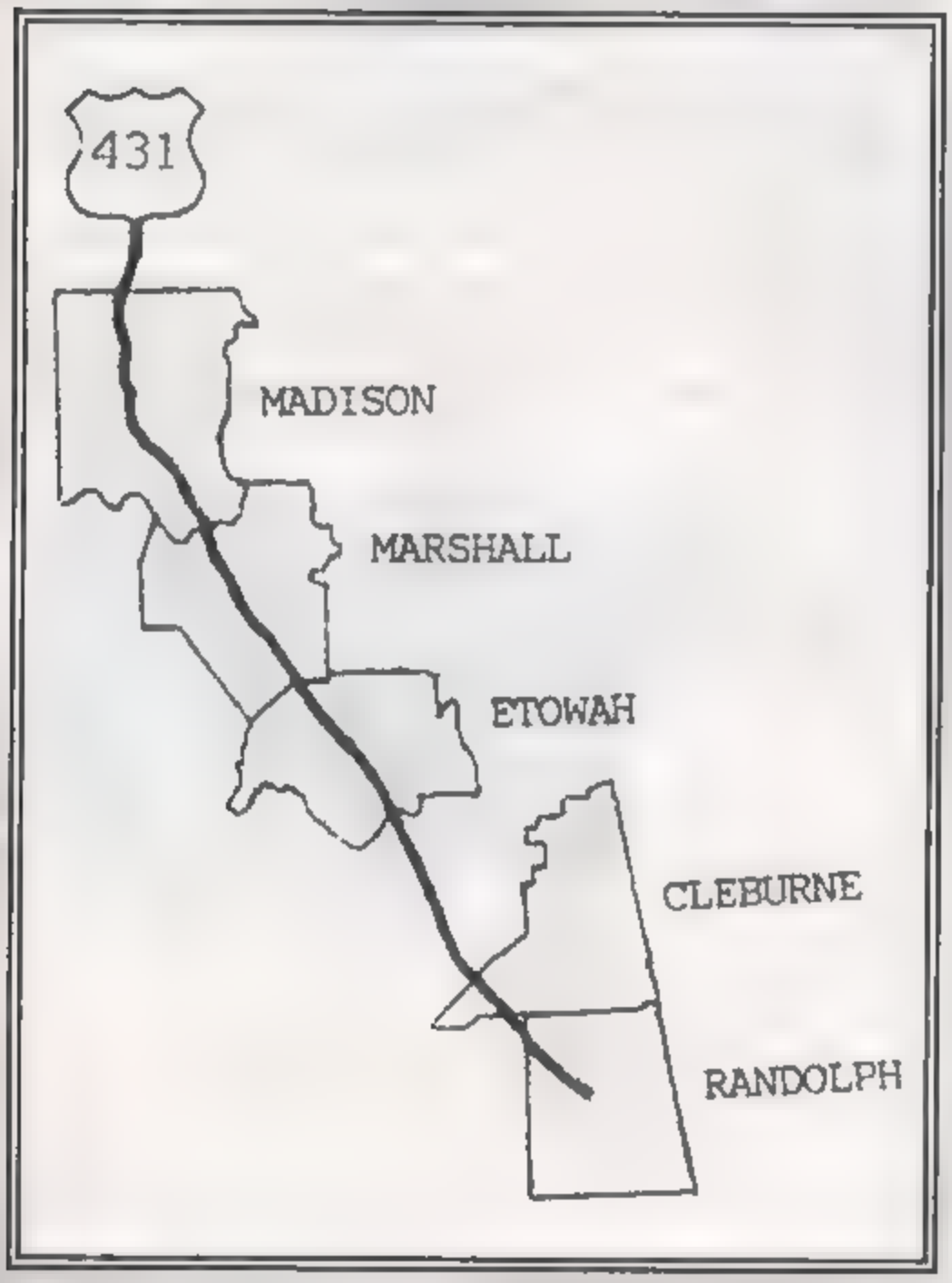
The less you have to dress your diamond drill, the better off you will be. Diamond drills manufactured utilizing Smart Cut™ technology require significantly less dressing than conventional diamond drills. Diamonds are oriented inside matrix so that every diamond is better able to participate in the drilling action. The bond renews itself. This unique open bond design ensures you get the maximum usage of diamond and bond. Smart Cut diamond bond also promotes a better coolant system. Air and coolant flow freely through the diamond bond, providing an additional source of coolant. Instead of heat being generated in a few places, it is evenly distributed and hence minimized. For a complete explanation of Smart Cut technology, visit the HKAM web site.

For more information about diamond drills, contact HKAM Industrial Superabrasive Tools, 25345 Avenue Stanford, Unit 211, Valencia, CA 91355, (661) 257-2288, fax (661) 257-3843, e-mail: info@hkam.com; Web site: www.hkam.com.

GOLD AND GEM HIGHWAYS

PANNING SITES ALONG U.S. HIGHWAY 431

Easy-Access Minerals in Alabama



by David and Clois Walker

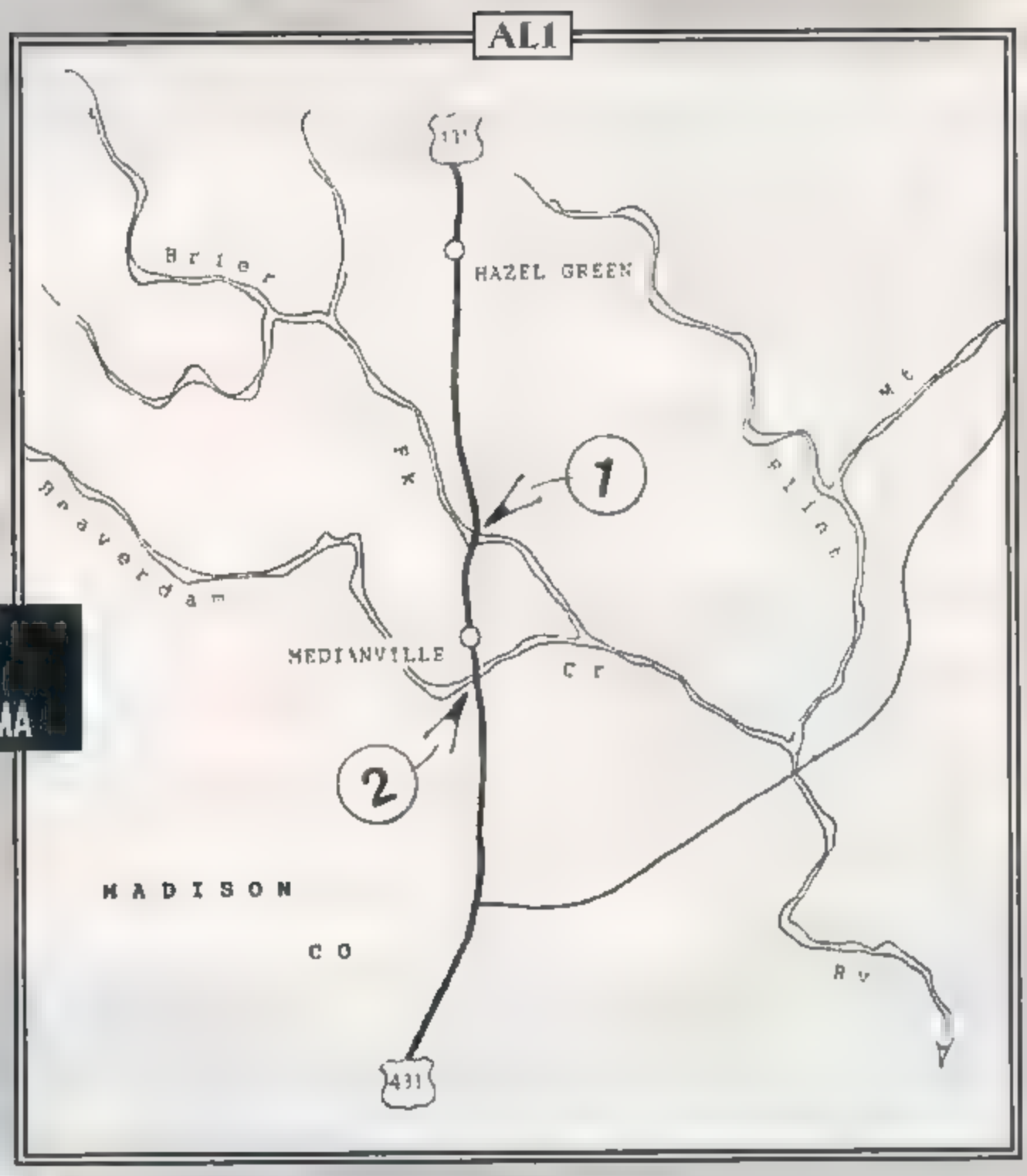
Situated as it is at the southernmost end of the Appalachians, Alabama showed mineral potential even before the infamous California gold rush of 1849. As reported by the U.S. Geological Survey PP-850, essentially all gold mining in Alabama is being carried on in the Arbacoochee and Hog Mountain districts. This study, however, embraces additional research pertinent to both gold and gemstone finds. Though rare indeed, pearls have also been found in Alabama streams.

With the above research to lean on, the next step was to plot the more appreciative finds on a USGS topo map, and with both the highway and drainage systems coming into play, we weren't all that surprised to see a number of highway stream crossings emerge from the overall pattern—the first few along U.S. Highway 431.

Standing up to the proverbial drafting board, we tied in sufficient detail for readily identification in the field—particularly evident when used in conjunction with the official state highway map for any of the five counties involved along the route. By popular demand, we've also included a county by county listing of both location details and the various minerals and gems reported upstream from each of the highway/stream intersections, again working on the premise that each and every rainstorm contributes to their downstream transportation. Also as many high-bank terraces and other solidified overburden are prevalent along some streams, it would appear the erosion concept may be relied upon over a period of years to come.

It must have appeared to most recipients of this study that limiting panning and screening activities to within established highway rights of way alleviates the otherwise necessity of locating and negotiating terms and conditions with private landowners. We advise you take a few more moments to convince the highway patrolmen you're well aware of, and have every intention of keeping, the ongoing safety and environmental regulations. Of course, lest this article be taken as a guarantee, please remember that Lady Luck has yet to be dealt with, and she is scarcely ever as cooperative as we'd like her to be.

SUGGESTED PANNING SITES ALONG U.S. HIGHWAY 431 IN MADISON COUNTY, ALABAMA



LOCATION AND VICINITY FINDS ALONG U.S. HIGHWAY 431 IN ALABAMA

Madison County (Map AL1)
Site 1 Crossing on Brier Fork of Beaverdam Creek, near MEDIANVILLE Vicinity finds include agate, jasper, and silicified wood
Site 2 Crossing on Beaverdam Creek, near MEDIANVILLE Vicinity finds include agate and chalcedony.

Marshall County (Map AL2)
Site 1 Crossing on Guntersville Lake, near GUNTERSVILLE Vicinity finds indicate quartz potential

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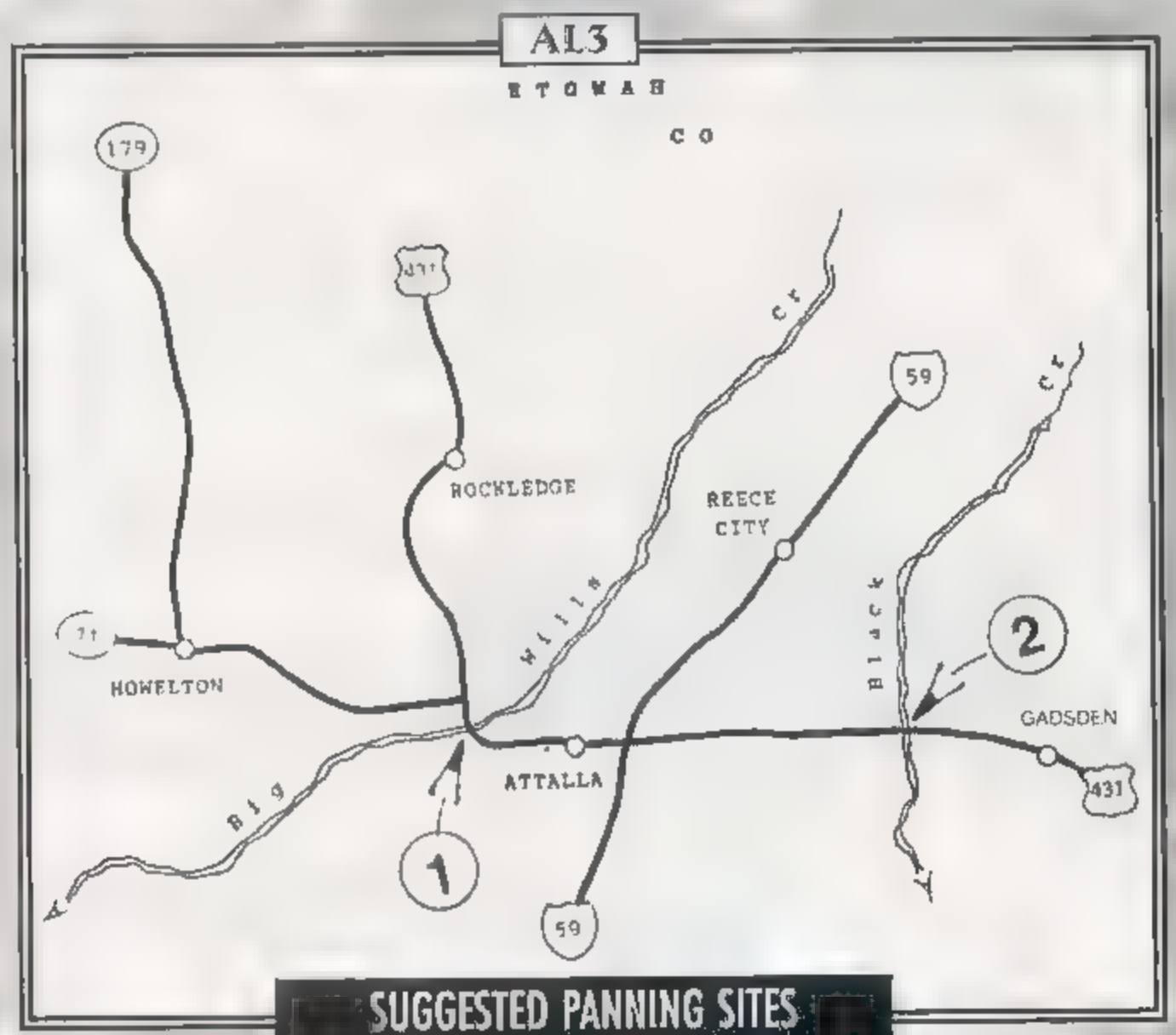
SUGGESTED PANNING SITES ALONG U.S. HIGHWAY 431 IN MARSHALL COUNTY, ALABAMA

Panning along U.S. Highway 180 *from page 35*



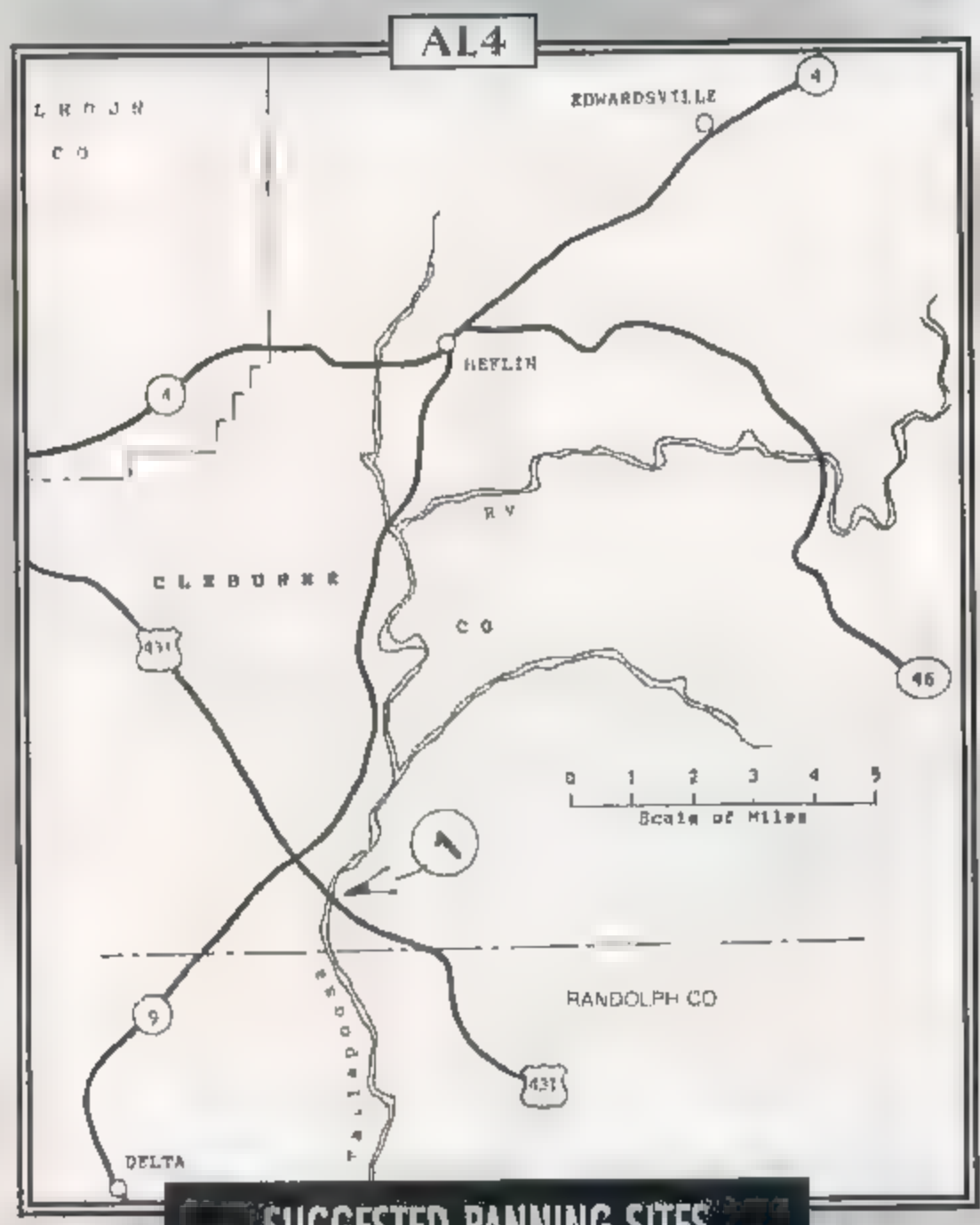
SUGGESTED PANNING SITES
ALONG U.S. HIGHWAY 431
IN ETOWAH COUNTY, ALABAMA

Etowah County (Map AL3)
Site 1. Crossing on Big Wills Creek, near ATTALLA. Vicinity finds indicate rhodonite potential.
Site 2. Crossing on Black Creek, near GADSDEN. Vicinity finds indicate rhodonite potential.

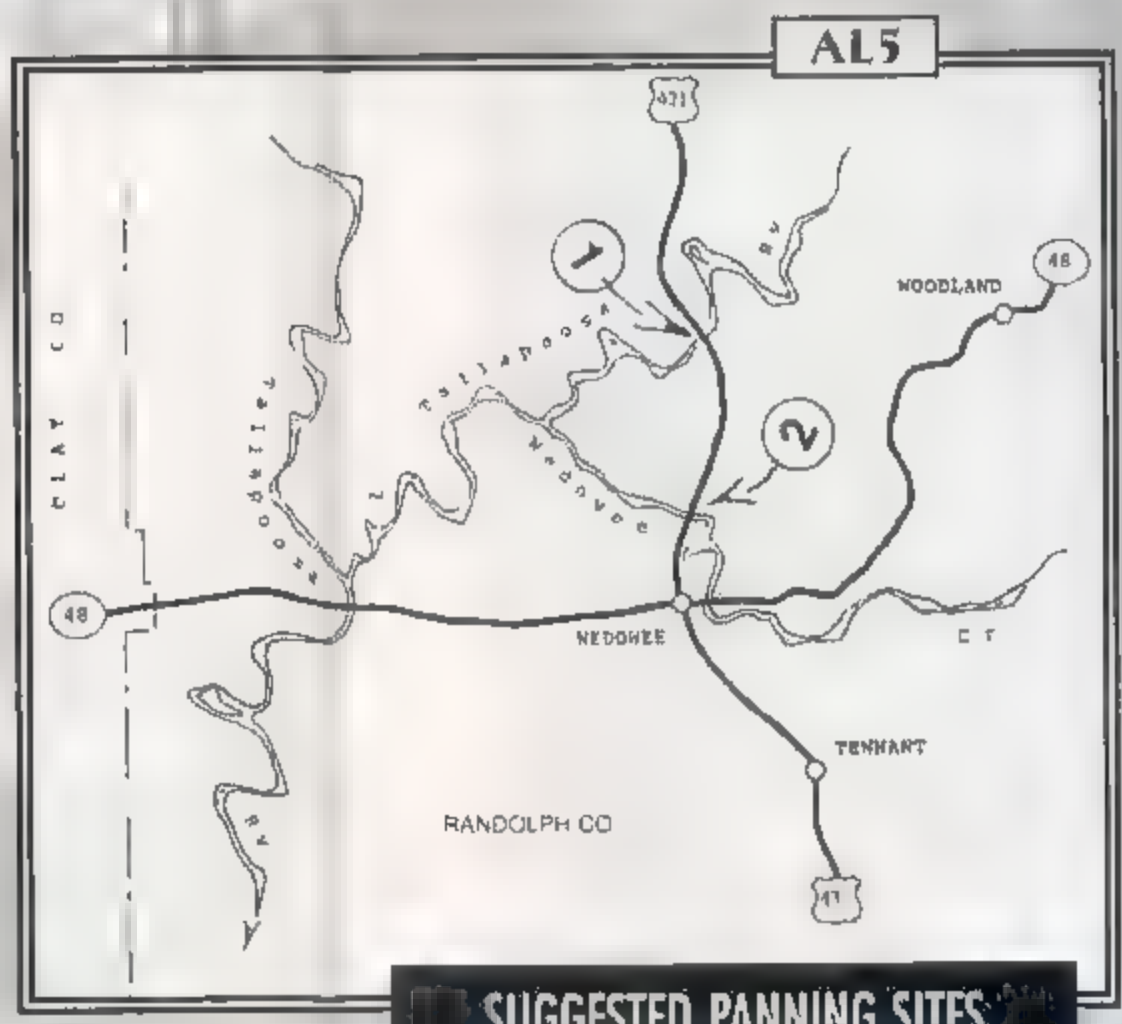
Cleburne County (Map AL4)
Site 1. Crossing on Tallapoosa Creek, near HEFLIN. Vicinity finds indicate gold potential.

Randolph County (Map AL5)
Site 1. Crossing on Little Tallapoosa River, near WEDOWEE. Vicinity finds include gold and quartz.
Site 2. Crossing on Wedowee Creek, near WEDOWEE. Vicinity finds include gold, quartz, rhodonite, and tourmaline.

The official state highway map is suggested, in conjunction with the vicinity maps, for overall orientation in the field. ◆



SUGGESTED PANNING SITES
ALONG U.S. HIGHWAY 431
IN CLEBURNE COUNTY, ALABAMA



SUGGESTED PANNING SITES
ALONG U.S. HIGHWAY 431
IN RANDOLPH COUNTY, ALABAMA

Rosebud County Moss Agate

FIELD TRIP

Carefree Collecting on the Banks of the Yellowstone River

I discovered this magnificent example of Montana moss agate on the Forsyth gravel bar. (Photos by the author)

This colorful piece of fossil wood is perhaps from an ancient pine species or a larch.

by Kenneth H. Rohn

While driving east in Montana on Interstate 94 recently, I decided to investigate two fishing access points. One is in the city of Forsyth and the other in nearby Rosebud, on the banks of the Yellowstone River in Rosebud County. I didn't want to go fishing, but rather to hunt for gemstones. I had learned from past experience that, on occasion, some of these access points are a good place to search. The gravel bars and banks of this river hold an abundance of stones of all sizes and shapes. Among them is Montana's state stone, the prized Montana moss agate.

I'll admit that I've collected my share of these beautiful stones, but the lure of adventure and the thrill of finding just one more agate among those tons of ordinary rocks is a challenge I cannot resist. And so it was that on a recent, warm spring morning, I took the Forsyth exit (93) and followed the signs to the river.

Forsyth is the Rosebud County seat, and the magnificent, historic courthouse is on the main street. It was rather easy to locate

I gathered this colorful selection of agates and wood at the Forsyth and Rosebud sites

the fishing access point and boat landing approximately a half-mile from the center of town; I just followed the "Rosebud East Fishing Access" signs. There's also a campground at the site, but at this time of year it was closed. No doubt it will open around Memorial Day.

When I parked my pickup and walked to the ramp, I looked out across the river to the far shore. I saw two men fishing upstream a way. The Yellowstone is about 300 yards wide at this point. It flows over a low rock breakwater a bit upstream of the boat ramp. I looked off to my right and studied the gravel bar. I found a narrow place, no more than 15 feet wide, where I could cross. The current was swift here, but not what one would call turbulent. At the deepest point, the water appeared knee-deep. There were a few stones closer to the surface, and I could see bigger cobbles in deeper water, but none were exposed. I decided to cross over a bit later. My first priority was the gravel bed on the beach downstream a short way from the boat launch site.

I found a path leading through the underbrush to this secluded beach. Exploring the area took the better part of the morning and I had no trouble finding several fantastic "keepers" of rather large size, plus a selection of very good smaller agates. It always amazes me when I find these sites, and wonder why (to our good fortune) they haven't been picked over.

Most of the agate nodules I collected at the Forsyth site are big. I saw some that were the size of a large grapefruit. I didn't take those, settling for smaller nodules, they're easier to work with. Most stones in this river are rounded off by constant water and gravel erosion. Of course, this also makes it difficult to identify them. Another deterrent is the accumulation of a mud coating on many of the rocks near the water's edge. It's a losing battle to try to wash every rock that you might want to examine, it's almost a certainty that there are few agates among them. So I usually just pass those by rather than waste valuable time.

I picked up a large piece of agatized wood on this beach that will make a great cabinet specimen. It's 6 inches by 2 inches by 3 inches, and resembles a piece of wood that's been scorched in a fire, with black and brown charred places. It is chocolate brown with black and tan growth rings; a fine example of fossil wood. It appears as though it may have been a soft wood, possibly a species of ancient pine, or perhaps a larch.

As I walked downstream on this steeply inclined beach, the rocks petered out and the bed grew narrower after a couple hundred yards. Soon, I encountered clay and fine sand. It was time to cross over to the gravel bar. I climbed the bank and followed the brush-cluttered path to the access road leading to the boat ramp. My rock pouch was full and it tugged at my waist, but I was confident that countless agates remained for other collectors. I had merely scratched the surface, but it had been a most successful morning.

Upon examining my collection in the camper, I saw that I'd done very well on the beach. I admired four nice chalcedony nodules that, quite frankly, resemble potatoes in shape and size, and strangely enough, somewhat in coloration, as well. It's rare when the interior of these stones can be seen, due to the rough surface caused by the grinding action of the river. The very dark ones sometimes, but not always, display the most beautiful interiors when sliced with a diamond saw.

continued on next page

Several of the stones that I collected on that gravel bed are a nice blue. Some are a most black, and it'll be quite interesting to see what their interiors look like. One never knows until the stone is cut or polished what will be revealed.

That reminds me of an incident on another field trip. Upon arriving home I had put a load of Montana agates in my 12-pound tumbler. Several days later, just before the final polishing stage, I washed the rocks thoroughly, and in doing so, noticed something unusual about one of the more colorful ones. I was astonished to discover a tiny, perfectly round platinum needle imbedded in one face. I really don't have any idea how deep this needle goes into the stone and I won't cut it to find out, because that would ruin it. I didn't finish polishing it for fear of wearing away the needle. So now it rests in my display case for everyone to admire. It's a most unusual and extremely rare specimen.

After a brief rest, I prepared for collecting on the mid-stream bar. I would take my camera and tripod to record my adventure, plus a container to carry rocks in. Instead of my pouch, I took a 2 gallon plastic pail. This way, I'd only have to make one trip over and back across the stream. The next thing I did was check the water for depth. It was, as I thought, no more than knee-deep in the middle, but the water was cold! So I decided to wear my wetsuit pants and boots. I had taken the suit along to do some metal detecting in any swimming beaches that I might encounter while on vacation. Now it would come in handy.

I dressed and walked down to the river. It was a piece of cake. The water was swift and it tugged at my legs in the deepest place, but I made certain of my footing before I took each step. I crossed upstream of the cobbles and made it across with no trouble.

Once on the bar, I noticed that it is much larger than it looks from the mainland. It stretches out for hundreds of yards downstream and is 300 or 400 feet wide in places. I never did walk to the downstream end of the bar. There was no need to; the area is so huge, it would take days to cover it all.

It wasn't long before I began finding moss agate. I picked up the most magnificent stone. It's oval with slightly rounded edges and fills my open hand. It is 1" inches thick and flat on both sides, as if it were sliced from a larger rock. Indeed, it was cleaved by nature, and if the other part could be found, it would also be a prize. This piece is completely filled with dark blue and white gnarled inclusions, so tightly packed together they resemble curled strands of hair all over the flat surfaces. As near as I can tell, these inclusions go through the entire stone. It's the most unusual pattern I've ever seen, a strikingly beautiful example of blue Montana moss agate.

I picked up a large, oblong chalcedony nodule the color of white wine with a speckled, snow white outer crust on one side and, from what I can determine, many black inclusions within. It's the size of a medium potato. I also found a lumpy orange agate 2 inches long and an inch thick, with a core the color of ice and dead white blotches throughout. It has a very glossy surface and must have been tumbling in the river for a long time. I discovered many blue/brown moss agates. One weighs 3 pounds and many others are upwards of 2 pounds each. It wasn't long before I became selective in my choice of keepers.

It was mid-afternoon when I made my way back to the narrow channel and forded the river. My bucket was heavy with agate nodules and petrified wood, but there were countless, more wonderful moss agates and pieces of agatized wood all over that bar.

After a brief rest, a cold glass of pop, and a sandwich, I was on my way to the second site near the town of Rosebud, 11 miles east of Forsyth, off I-94 exit 103. Shortly after crossing the Yellowstone on the way to the community of Rosebud, you'll see the Fishing Access sign. Turn left and follow the gravel road for a short way to the access point, boat ramp, and campground.

I discovered an excellent gravel bed on the beach, loaded with tons of water-worn rocks of all sizes, at this second site. It spreads out on both sides of the boat launch ramp, and although it's not as wide as the Forsyth gravel bar, it goes downstream for a great distance. The water was low when I visited, due no doubt to a dry winter east of the Rockies.

A narrow band of rocks close to the water was covered with a thin coating of mud, but the rest of the beach stones were very clean. I had no trouble identifying agates as I slowly walked along, looking for that telltale glint of translucence common in most chalcedony nodules on a bright sunny day.

I had the place to myself. The campground was open, and I saw no pay booth or any place where one would deposit a campsite fee. Off-road parking is permitted in Montana, and this might account for that. However, the people of the community of Rosebud and others in the county must volunteer their services to maintain such a site. I take my hat off to them.

I walked very slowly downstream, searching for moss agate with those inclusions that make these stones so desirable. As is usually the case, a slow, methodical gait is best for locating them. Once in a while, a stone can be picked up that looks as though it had been polished in a tumbler. Those are easy to identify. At the same time, I kept looking for that telltale glint of translucence, a sure indication of chalcedony.

Unlike many stones with a visible habit, cryptocrystalline quartz is composed of superfine crystal needles, impossible to detect with the most powerful microscopes until recently. To the naked eye, or even through an eye loupe, the material appears to be one solid mass (except for the banded variety). One of the confusing aspects of collecting any agate material is the fact that no two specimens ever seem to look alike.

I searched a narrow band on that beach most carefully, but I'm certain that I missed many nice stones, simply because it's almost impossible to cover such a large area in the course of a few hours. One could literally spend days here and be able to collect agates every day. I'd be willing to venture. I've often thought, if only one could examine the tons of rock just a few

inches below the surface what treasures we'd find. Of course the next high water runoff will reveal some of those stones and probably cover up others. It's a continuing process of nature.

My wanderings had taken me down to the bend in the river possibly a couple hundred yards. On the way back, I filled my rock pouch with agate nodules of various sizes. Long before I reached the ramp I had been extremely selective and only searched a very small portion of that beach. It was getting late. Old Sol was dipping toward the western horizon when I finally decided to call it a day. It had indeed been a very fruitful collecting experience.

Although these stones are categorized as sempreservus, I like to think of them as precious simply because they were formed so far back in the past that the human mind has great difficulty in comprehending such a time span. Maybe new ones are being formed as you read this, but I wouldn't want to bet on it, and if they are, we will never see them in our lifetime. So it's safe to say that this is a nonrenewable resource. We quite possibly will never see that time, but when they are gone, there will be no more. So let's consider it a luxury that we are able to collect such magnificent stones, a product of the dim, distant past, and hope that future generations can do the same.

As the sun began to set, I made my way back to the highway and headed east toward Minnesota and home. It had been an exciting field trip, and I was able to collect some of my favorite stones: Montana moss agate.

The rocks of the Rosebud gravel beds were very clean, which made it easy to identify the agates and petrified wood.

India's Ancient Mining Heritage

It's One of the World's Earliest Mineral Sources

Ancient miners used this method to extract gold from the Chitradurga green stone belt in Karnataka. (Photos by the author.)

by K.R. Raghu Nandan

India is considered one of the world's earliest sources of mineral treasure. A reference to Indian gold is made in the Bible. The name Ophir, mentioned in the holy text, is ascribed to India. Indian civilization is one of the world's oldest, and the country also has the distinction of recording an ancient mining history over 3,000 years old.

A list of mineral commodities that were known and mined includes gold, silver, copper, zinc, lead, iron, and tin, and a variety of gemstones, including diamond, emerald, ruby, and sapphire. Even the use of coal was known from time immemorial.

The importance of mines and mining as a source of revenue for the state was well recognized in ancient India. Kautilya, an economist and prime minister to the Mauryan emperors during the third century B.C., refers in his classic *Arthashastra* (a treatise on economics) to the industries owned, managed and financed by the state, which included mining and smelting of precious and other metals, gemstones, and salt. He wrote in the Sanskrit language "Akaran Prabhavah Kosha," meaning "The mines are the source of treasury." As known from history, mining activity was at its peak during the Mauryan period (the second and third centuries B.C.).

The ancient mines (in the form of pits, open stopes, trenches, chambers, galleries, shafts and inclines), mine debris and slag heaps, digging implements, pestles and mortars, and various types of grinding stones in gold-bearing areas left by the ancient miners bear ample testimony to the skill they developed not only in mining the metalliferous ore deposits, but also in smelting the ore to recover the metals. During the ancient times, mining operations were naturally manual. Some mines are large and wide, while most of the old mines are small, with tortuous, narrow drifts. At present, they are mostly in the form of pits or depressions. Some are remarkably well preserved. Although they are open at the surface, they are generally filled.

During my career as a geologist engaged in prospecting and exploration for ore deposits, I have examined numerous old mines and studied the available records in different parts of India. I was deeply impressed by the knowledge of ancient miners in identifying metal-bearing outcrops. No exposed gold-bearing quartz reefs appear to have been left unworked

Many placer deposits—especially of gold and diamonds—were exploited

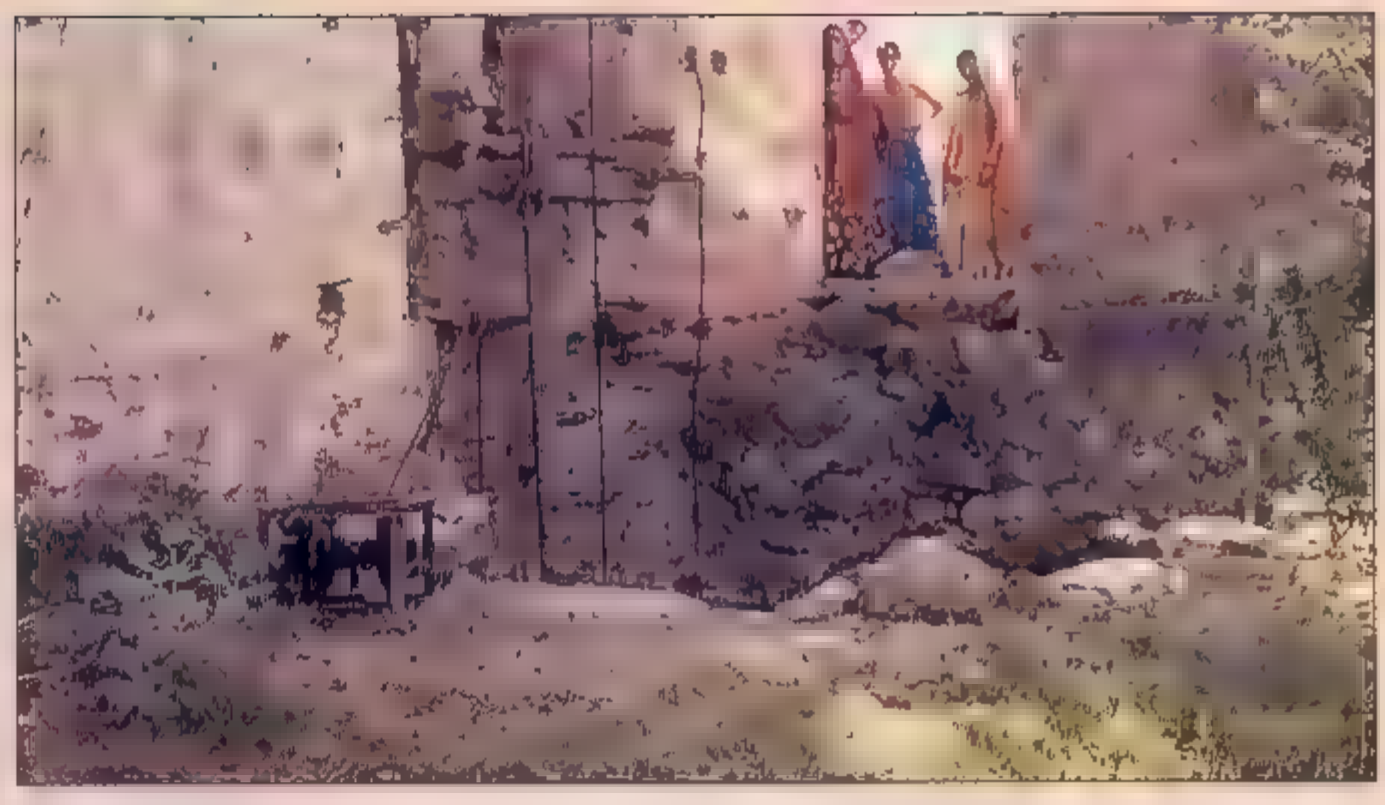
In the absence of explosives, the normal method of underground excavation was "fire setting." At or near the mine-head, a quantity of firewood was stacked and set on fire. The presence of charcoal, charred pieces of wood and soot on the smooth rock faces confirms this theory. After two or five days, the miners would descend into the mines, where the rocks would have broken and split into large blocks from the heat. It is recorded that to ensure fracturing, water was poured on the hot rocks.

As the mines got deeper and encountered the water table, they faced waterlogging, and dewatering was carried out with the miners forming a human chain from the mine head to the gallery, passing pots filled with water. This method of dewatering was practiced in many ancient metalliferous mines, including copper mines in Khetri (Rajasthan) and gold mines in South India (Hutti and Gadag in Karnataka), as evidenced by the accumulation of fragments of earthen pots at the bottoms of the mines.

Some of the shafts were partly or fully lined by lime or mortar. Some shafts were meant only for the miners' entry, while others were used for ventilation or for the haulage of ore or waste. The stone slabs at the collar of the shafts in some mines suggest that mined material was hauled up over a pulley, supported on a single upright wooden post that was forked at the top. In some mines, small hollows made at the sides were probably resting places for the miners during their ascent and descent.

I have read in some old records of how a miner worked in a copper mine in Khetri during the ancient times. A miner would squat on his heels with an earthen lamp on his head and a basket between his knees, and strike the ore-bearing walls with a chisel and hammer. As the ore-smelting technology was limited at that time, they could extract metal only from rich patches of ore and not from the low grade ore, as this would mean treating a large volume of rock. Therefore, the miners' baskets would mostly contain ore fragments high in metal content. Usually, the broken ore put in the bamboo basket was passed from one miner to the other till it reached the surface of the mine.

In the eastern part of India, ancient mine workings and slag heaps found all over the Singhbhum copperbelt in Bihar and its extension to Orissa state) bear testimony to a once-flourishing copper industry. Stone implements recovered near Tarandih point to the antiquity of the workings. During a survey of old workings, certain pits yielded copper coins of the Kushan period (50 B.C. to 210 A.D.). The widely scattered slag heaps, carefully worked-out old stopes, and ancient mine dumps highlight the skill and ingenuity of the miners who worked them about 2,000 years ago.



The shaft of an ancient lead mine now serves as a well in Ghugra, Rajasthan.

The mining of lead-zinc deposits in Rajasthan, Agucha and Ajmer dates back 2,500 years. Silver was also extracted from some of these deposits. The available data suggests that mining was at its peak during the 13th to 15th centuries, and a highly advanced and prosperous zinc mining/smelting industry thrived at Zawar. Zawar was not only one of the earliest centers of zinc production in the world, but was also considered to be the direct ancestor to the processes of high temperature distillation developed in the 19th and 20th centuries in some countries of Europe.

Ancient gold mines in Karnataka state are more than 2,000 years old. Carbon dating of timber from the Village shaft at Hutti has given ages between 1,740 and 1,960 years. Gold mining in general declined toward 600 A.D., with a brief revival during the 16th and 18th centuries.

It has been described that the ancient miners worked the reefs in a manner similar to the present-day practice, i.e., by going down on the reef through small shafts and then extracting the ore laterally, in what is today termed "flat back open overhand stopes." Rope markings on the footwall rocks and on timbers in the old workings are suggestive of the use of some form of windlass to hoist the ore and waste rock in a basket. The deepest old mine for gold—620 feet deep—is in the Hutti goldfields of Karnataka.

The gold-bearing ore thus mined was crushed with the help of heavy boulders. Depressions in the hard rock (6 inches broad and 4 inches deep) indicate sites for further, finer grinding. Such pounding sites are very common near ancient mines in the gold belts of south India. The artifacts found near many ancient mines include pestles, mortars, and huge boulders. Extensive distribution of such artifacts in the Kolar, Hutti and Gadag gold fields in Karnataka, in the Ramgiri gold fields in Andhra Pradesh, and in the Bihar gold fields bear ample testimony to a once-flourishing gold mining industry.

Bhukia in Rajasthan was identified in 1993 as an old gold mining center. An ancient tribal temple, Hiranya Bee wa Maa (dedicated to the goddess of the land of gold), exists in this area, built perhaps by the ancient miners as a thanksgiving gesture to the deity—a common practice in the ancient times. I have observed during an examination of Bhukia's old workings small mounds of reddish brown clay in the vicinity. This would suggest that the weathered and oxidized zone was crushed and washed to recover free gold. The residual clay still contains fine grains of gold, which were left by the old miners.

The skill and knowledge developed by ancient miners, apart from the historical importance, highlights their ability to exploit the Earth's mineral treasures, especially, as good prospectors well-versed in the identification of ore deposits. It can be best described that they have left their footprints in the form of old workings all over the country. To quote Allchin F.R. (1962), who carried out a detailed study on the antiquity and methods of gold mining in ancient India, "The achievement of the old miners remains a matter of wonder, to be set besides the other records of early mining, be they in Egypt, Sinai, Cyprus or Greece."

In addition to acquiring knowledge on the methods of mining and smelting adopted by the ancient miners, the examination of sites of ancient mining activities has proved to be of immense value in carrying out exploration and prospecting operations by geologists in modern times. Most of the present day producing mines of copper, lead, zinc and gold metals in India represent such sites of ancient mining and smelting activity.

FIELD TRIP

Finding Facet-Grade TOPAZ

Screening sand and crushed rhyolite is a low-energy way to recover topaz crystals. (Photos by the author)

Topaz Mountain, Utah, Doesn't Disappoint

by Squy Wallace

Delta, Utah, is in the center of a rock and gem hunter's paradise! This small town in southwestern Utah is noted for its beautiful topaz stonstones, trilobites, and geodes. Delta is located southwest of Provo, Utah, and was our last stop before heading to Topaz Mountain in late May of 2002. We were very successful at finding beautiful facet grade topaz during our two-day gem-hunting excursion. The day we spent in Delta visiting rock shops before heading out to hunt topaz was especially helpful and informative. We found that the key to a successful gem hunting trip was following the advice we got at the rock shops.

Finding topaz at Topaz Mountain is not about breaking up big rocks or climbing dangerous mountain trails. Rather, it's all about finding the right location, and using the knowledge and proven techniques learned at the rock shops. My wife, Bea, didn't want to pass up an opportunity to go shopping at the two rock shops in Delta. These shopping trips proved to be exceptionally valuable in our search for topaz. There are two rock shops in town, Neno's Rock Shop & Guide Service and West Desert Collectors.

Shirley Schena and Nina Higgs at Neno's Rock Shop were exceptionally friendly, helpful and knowledgeable. Ask them about Topaz Mountain and they will provide a wealth of information including examples of topaz, how to hunt and dig, and how to get to the site. They also have an excellent collection of tools, mineral specimens, cabbing material, and several books and pamphlets that we found especially useful and valuable. Neno's Rock Shop has all of these sources available at a nominal cost. Buy these books at Neno's *before* you leave Delta.

West Desert Collectors rock shop is owned by Bob Harris, who also does wholesale manufacturing of a wide variety of rock products. Take some time and visit with him. He also owns an active trilobite mining claim not far from Delta. Bob was kind enough to allow us to spend some time going through the tailings of his mine.

One additional resource we found to be of great help is the Web site www.minmarket.com/TopazMtn/Topazmtn.html. This is a great place to start planning your trip. It has clear maps, mileage and distance charts, tips on hunting for topaz, great photos of some spectacular topaz speci-

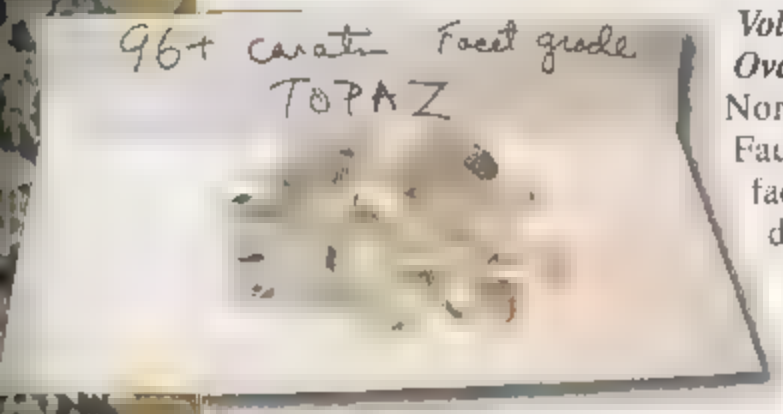
Helpful References for Hunting Topaz

BOOKS

A Field Guide to Topaz and Associated Minerals of the Thomas Range, Utah (Topaz Mountain), Vol. I, by John Holfert, Walter Mroch, and Jeremy Fuller (1996, HM Publishing). Distributed by Utah Mineral and Fossil Inc. (www.utahmin.com), this is the definitive guide on Topaz Mountain. It includes maps, collecting tips and insights, geology, photos of the area, and an extensive collection of color photos of topaz found at Topaz Mountain. This book can save you many hours of fruitless work. Finding topaz at Topaz Mountain is all about location, knowledge and technique. This book is available at Neno's Rock Shop.

The Traveler's Guide to Rocks and Fossils In and Around Millard County (Millard County Tourism). This booklet is priced at $2.50 and is one of the best buys you will find in mineral and gem collecting. Included with the book is a fold-out map that covers a large portion of Millard and Juab counties. With this booklet and map, you can easily find your way to collecting sites for topaz, geodes, obsidian, agate, trilobites, and labradorite. This booklet is available at Neno's Rock Shop.

Gem Trails of Utah, by James R. Mitchell (Gem Guides Book Co.). This guide covers many Utah gem and mineral collecting opportunities other than the topaz discussed in this article. Take a little extra time and visit some of the collecting sites as you travel through Utah. This book is available at Neno's Rock Shop.



Volume I, Facet Design Ovals, Robert Long and Norman Steele (Seattle Faceting Books). This faceting book has hundreds of diagrams and cutting instructions for almost every imaginable oval facet design. Long and Steele pioneered the concept of "meetpoint" faceting, which yields exceptionally accurate placement of facets. This book uses the meetpoint faceting techniques demonstrated in their first book, titled *Introduction to Meetpoint Faceting*. It is available from Seattle Faceting Books, 2232 78th Ave. S.E., Mercer Island, WI 98040.

INTERNET

www.minmarket.com/TopazMtn/Topazmtn.html Start your search and planning at this Web site. Here you will find maps, hunting tips, and volumes of information you will need to make your trip a success. You can download enough information here to drive to Delta, Utah, locate and visit the rock shops, and start your hunt for topaz.

ROCK SHOPS

Neno's Rock Shop & Guide Service, 648 W. Main St., Delta, UT 84624, (435) 864-4143. Folks here are very friendly and helpful. They focus on answering your questions and giving sound advice on making your trip a success. Spend some time visiting, looking around, browsing and shopping. We found several excellent books and crystal and mineral specimens at Neno's.

West Desert Collectors, 278 W. Main St., Delta, UT 84624, (435) 864-2175. Bob Harris, the owner and manager, offers a wealth of knowledge and information about rocks, minerals, and fossil and gem hunting. He manufactures and wholesales polished septarian and Picasso buffalo, bear and egg carvings. His shop is also an excellent source for cabs, balls, bookends, and beads.

We bought several sizes of his unique septarian buffalo carvings. You will find these same carvings in the Salt Lake City Airport shops for many times the price Bob was asking. They make great Christmas gifts. Bob also has several lapidary machines that he uses to make his carvings and spheres. Listening to Bob explain how the machines work is like getting a personal factory tour of one of America's last rock art manufacturing shops.

Bob also owns a trilobite mining claim that he actively works. He wholesales the trilobites and sells them in his store. Talk to Bob about his trilobite mine. He may even be persuaded to let you spend some time going through the mine tailings.

mens discovered at the mountain, and general information about the area. Start here to plan your trip, download the maps and mileage charts, and spend some time studying the map of Topaz Valley.

There are more than 200 moderately priced motel and hotel rooms in Delta. Tent and RV camping sites are available at the Antelope Valley Campground on West Main Street, which provides full RV hookups and modern, clean showers. The warm shower was especially welcome to our sore muscles after two days of digging on Topaz Mountain. There are several good restaurants in Delta that provide excellent meals. The museum is also worth a visit, it has much information about Topaz Mountain and the history of Delta.

After spending a day and a night in Delta, we headed off to Topaz Mountain, which is about 35 miles west of Delta. The first 30 miles is good, smooth blacktop road. The last five miles or so is on Bureau of Land Management (BLM) washboard gravel roads that quickly deteriorate to drivable two-wheel dirt trails. Drive slowly over these roads. A four wheel-drive vehicle is *not* necessary to travel them; we saw many two-wheel-drive cars and trucks successfully make the trip. Following the map we downloaded from the Topaz Mountain Web site and the one we picked up at Neno's Rock Shop got us within 50 yards of our first topaz collecting site! There are numerous pullouts along the BLM roads and trails that serve as good parking spots and campsites. There are no improved camping facilities at Topaz Mountain, so be prepared to rough it with no facilities, or plan to drive back to Delta at night.

How do you know when you are there? There is a clearly defined and unmistakable "notch" in the mountain range to the east of Topaz Mountain. When you see this feature, look to the north and you will see well-defined bare areas on the mountain where rocks and rubble remain from past blasting efforts. If you are in good physical condition, you can hike up to these areas and hunt for topaz by chipping the rhyolite or scratching in soft areas and cavities to recover the virgin sherry-colored topaz. A screwdriver, mechanic's screw grabber, or an L-tipped wire tool are excellent for carefully removing the fragile topaz from the rhyolite cavities.

continued on next page

Finding Facet-Grade Topaz *from page 53*

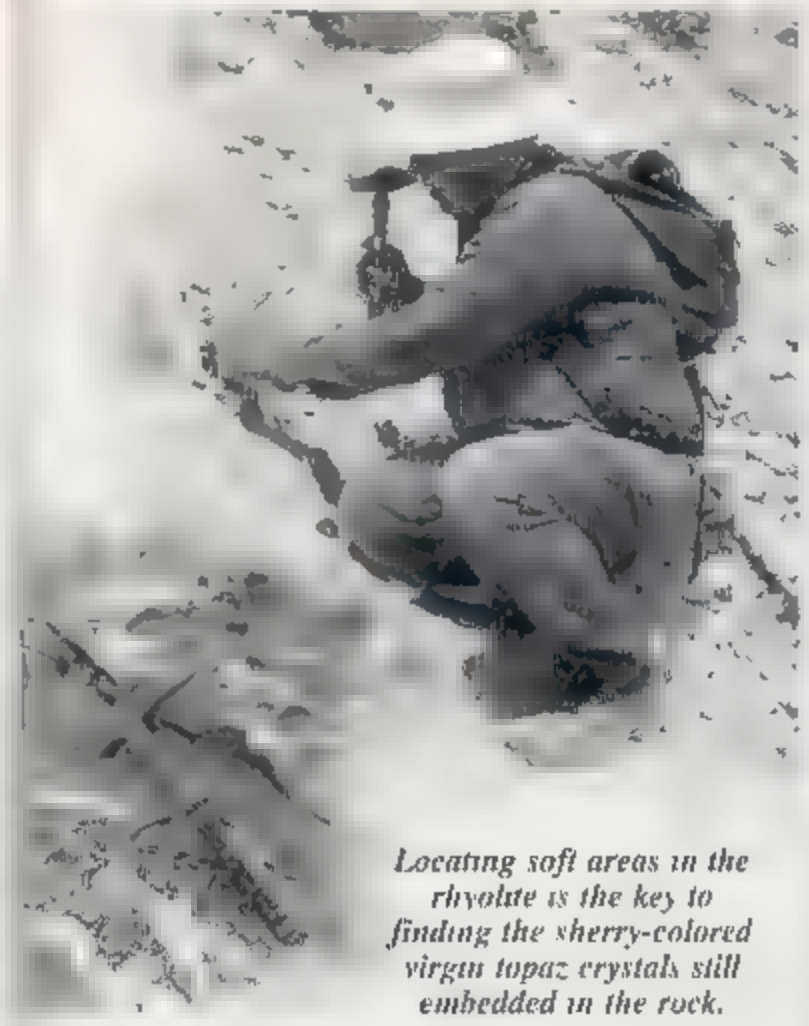
The topaz in this area has a nice yellow to orange color that fades to clear white if exposed to sunlight over time. The sherry-colored topaz taken from the rhyolite cavities makes excellent mineral specimens and clearly demonstrates the crystal growth habit of topaz. The gray rhyolite is highly pocked with cavities from expanding gas bubbles that percolated up through the molten rhyolite several million years ago. As the gas cooled, the topaz crystals were formed in the cavities. Some of the crystals are opaque and some are poorly formed, but many of them are beautiful, clear, sherry-colored crystals. The crystals seem to have formed in groups or clusters. Wherever you find one, look carefully because there are usually more close by.

If you are less physically fit and not inclined to "billy goat" up the sides of mountains, there are other productive ways to find topaz. We found several washes or small ravines where we screened the sand and crushed rhyolite. If you are not inclined to go rock climbing and want to avoid sore muscles and an aching back, this is an excellent low-energy way to hunt for and find topaz. We screened two or three different washes and found many nice, clear, 3 to 5 carat white topaz crystals.

Another way to find the crystals is to walk around between 10 a.m. and 2 p.m., when the sun is shining, and look for sparkles on the ground. Bea found several nice crystals just by walking around and scraping the soil with a screwdriver wherever a sparkle occurred. In fact, she found a 5 carat, perfectly formed facet grade clear topaz crystal about 30 feet from where we camped for two nights! Another suggested way to hunt for the crystals is to use a bright flashlight at night and dig around any sparkle that reflects the light! Be careful, there are rattlesnakes and scorpions in the area! We started to try this technique, but were so awed and amazed by the clear, dark skies that we spent a couple of hours just looking at the Milky Way, the constellations, the planets, and the satellites passing overhead. We will try the flashlight method of hunting for topaz on our next trip.

We met several gem hunters during our stay at Topaz Mountain. All of them were helpful and friendly, and quickly shared information about their finds. One of the best hunting tips we got came from a member of the Kalispell, Montana, rock and gem club. He and his family had been to Topaz Mountain before and had a wealth of topaz hunting knowledge and experience. We quickly adopted his "lazy man's way to hunt topaz." He showed us how to carefully work through the dust and debris left from previous blasting and mining efforts. Amazingly, many beautiful, clear sherry-colored topaz crystals lay just an inch or two under the rhyolite dust! Carefully scraping our fingers through the dust revealed several nice crystals. One wonders how these crystals could withstand the shock of a powerful blast and still remain intact and undamaged.

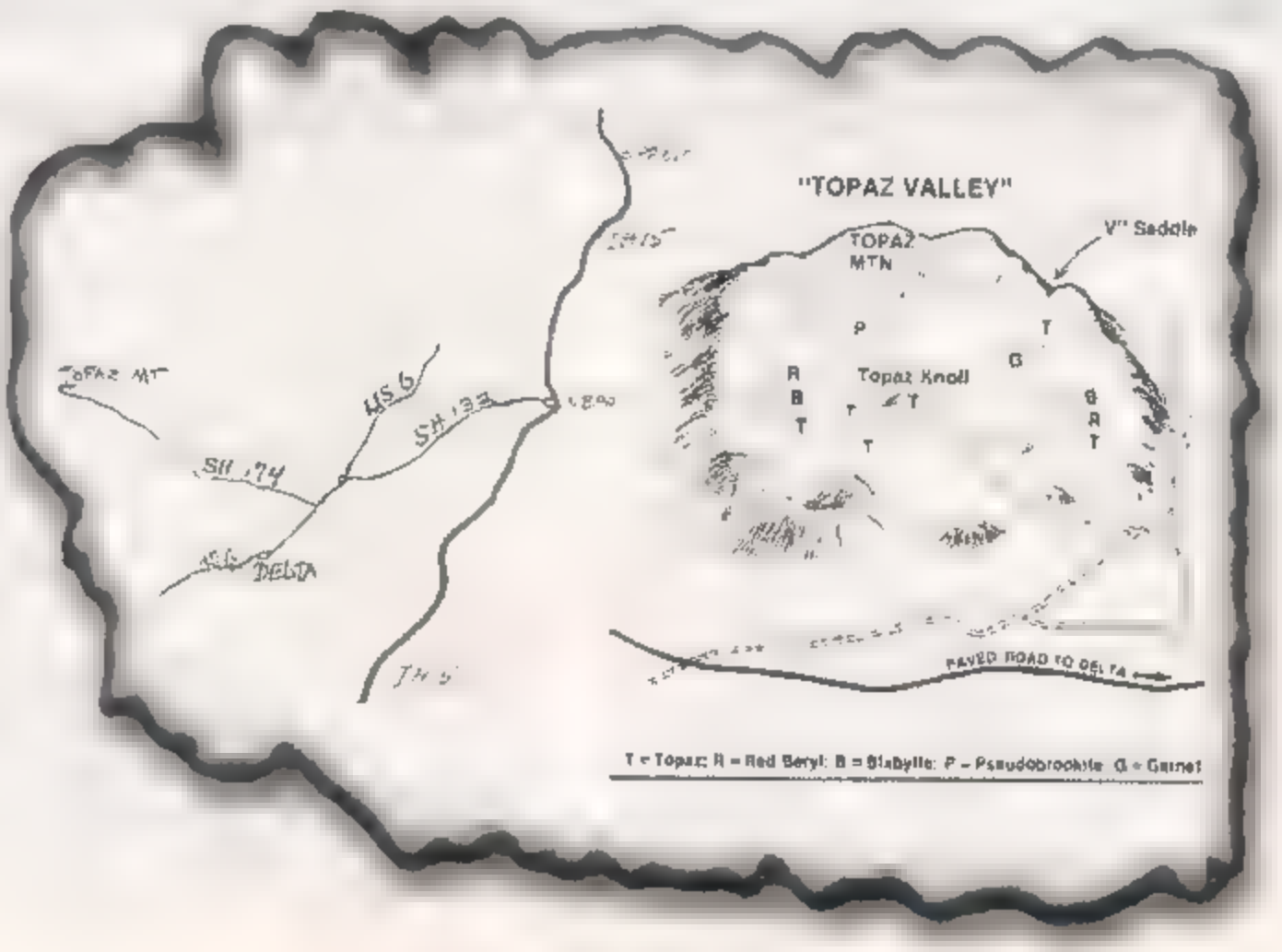
After two days of collecting, we sorted our crystals and were pleasantly surprised to find that we had collected over 96 carats of beautiful, clear, facet-grade topaz. When we got home, I faceted one of the crystals into a beautiful 5 mm by 7 mm oval for Bea using the facet patterns from Long and Steele's "mix and match" crown and pavilion meetpoint faceting designs. The finished gemstone clearly shows the reflective beauty of a highly polished faceted topaz. Bea treasures the stone for its beauty and for all the wonderful memories of our gem-hunting trip. The Montana winter won't seem long or cold this year as we reminisce about our trip and as I dop our topaz crystals to facet into more beautiful gems.



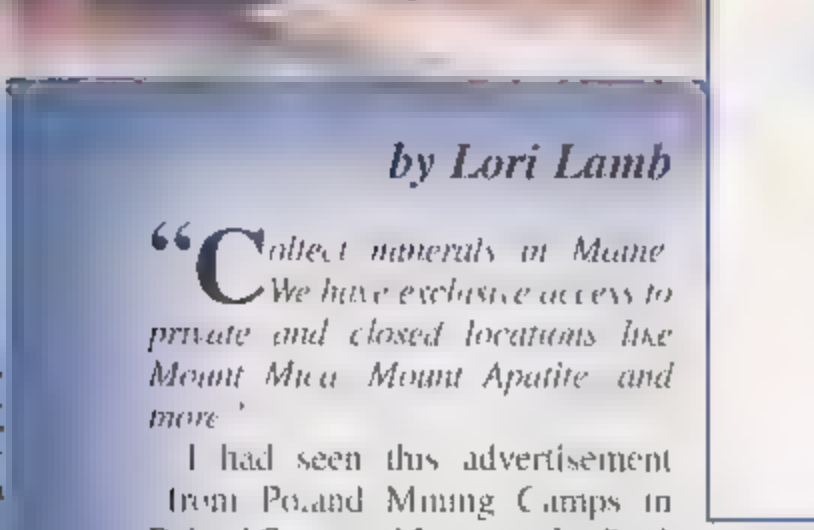
Locating soft areas in the rhyolite is the key to finding the sherry-colored virgin topaz crystals still embedded in the rock.

A few words of caution. Even though we made this trip in May, the temperature was beginning to warm up into the high 80s. Several topaz hunters we visited with told us to avoid the area in late June, July and August. They indicated that temperatures can climb to 120 degrees during the day! We didn't encounter any dangerous creatures such as rattlesnakes or scorpions, but they are known to live in the area. Also, take sunscreen, insect repellent, and a broad-brimmed hat to shield your skin from the sun. If you plan to be away from camp for more than a couple of hours, take plenty of drinking water. The air is dry and it's easy to become dehydrated while enthusiastically searching for topaz.

The Delta area offers many excellent opportunities for gem and mineral collecting. Topaz Mountain is the premier location for finding excellent collector's quality sherry-colored topaz and good faceting crystals. Plan your trip, read the references, talk to the rock shop owners and head for Topaz Mountain for a great collecting trip.



Collecting at Poland Mining Camps



Additional collecting sites were found near Topsham and Brunswick. (Photos by the author)

Maine's Pegmatites Prove a Mineral Cornucopia

by Lori Lamb

"Collect minerals in Maine. We have exclusive access to private and closed locations like Mount Mica, Mount Apatite and more."

I had seen this advertisement from Poland Mining Camps in Poland Springs, Maine, in the *Rock & Gem* classifieds more than a few times. The lure of "private" access to "closed" locations gave me visions of mineral glory holes of tourmaline and apatite.

It was once again time to plan our summer vacation. My husband and I are indeed serious rockhounds; I have actually scheduled an entire vacation around access to Sterling Hill, New Jersey. A rockhounding friend had visited Maine the previous year and raved about the cache he had discovered in the state's pegmatites. Remembering this, I pulled out the ad and dropped a note to Dudy and Mary Groves, the owners. They quickly responded with information about a vacation package and services. The season runs from Memorial Day to Sept. 30. Rates include lodging in a small private cabin, three meals a day, liability coverage, access to all mines and private quarries, and the services of a guide. After reviewing the information, I secured our reservation.

That covered the heart of the trip, but to be sure I did not miss any good sites in the areas around Oxford and Androscoggin counties, I accessed the Internet. I also ordered the book *A Collector's Guide to Maine Mineral Localities*, by W. B. Thompson, D. L. Joyner, R. G. Woodman, and V. T. King (Maine Geological Survey). These sources provided maps and directions to numerous collecting sites in Maine, and some helpful insight into the history and geology that bears such renowned treasures.

The majority of the state is underlain with metamorphic rock. It is most intense in the southern part, where the bedrock is often intruded by granite plutons. In northern Maine, the metamorphosis is only slight, with some of the original sedimentary layering preserved. This distribution helped define the location of Maine's mining history, the focus being in Oxford and Androscoggin counties. The mining history itself is dual in nature, with commercial feldspar mining and gemstone mining playing prominent roles. The common denominator is the granite pegmatite.

Granite pegmatites are characterized by a coarse texture and visually distinct, large individual mineral crystals within the matrix. These are formed by the gradual cooling and solidification of fluids derived from igneous rocks that have been exposed to heat and pressure. The slower the cooling, the larger the individual crystals become, as a rule. Sometimes crystals in pegmatites are measured not in inches, but in feet. The famous beryl crystals found in the Bumpus Quarry in Albany in the 1920s measured 18 feet long and 4 feet in diameter.

Pegmatites can occur in two patterns. "Simple" pegmatites have an evenly distributed complement of minerals throughout, with quartz, feldspar and mica randomly dispersed. "Zoned" pegmatites have two or more zones, or layers, of distinct mineralogical composition. This layered composition is often repeated at many sites in a region, so miners learn the sequence and use this as a guide for finding desired gem specimens. I heard one miner say that when you hit the garnet layer, you have gone too far to find "the good stuff," the tourmalines they seek.

When mineral collecting in a Maine pegmatite, one must be aware that the various mineral specimens that crystallize occur in two ways. Some are tightly encased in the rock matrix, the quartz and feldspar having grown closely around them. This is typical of beryl, schorl (black tourmaline), almandine garnets, green apatite, and columbite. Successful extraction of these mineral specimens requires hard rock work with hammer and chisel and a modicum of luck. The desired specimens sometimes break with the matrix. Less frequently, under the right geologic conditions, the minerals grow into cavities called vugs. These crystals tend to be clearer and of higher quality. Such is the case of the most sought after Maine gemstones, watermelon tourmaline (or elbaites), purple apatites, and rose, amethyst, and smoky quartz.

In their heyday, the quarries around Paris and Newry boasted pockets large enough for a person to sit in. A typical pocket is usually defined by a predictable sequence, one that miners use as a compass to their treasure. Early excavation will yield rock of quartz and schorl in a tight formation. Next, one may encounter lepidolite, lithium-rich mica that often signals the presence of a pocket. Following the lepidolite as it "runs" into the pocket can lead to a cavity lined at the top with quartz, mica and cleavelandite. In the lower half, there is a whitish clay, which is really decayed potash of feldspar. Geological disturbances over time have tended to break the crystals from the walls, and it is here in this clay that the desired elbaites (watermelon tourmaline) reside. Occasionally, there are "dead pockets" that contain no gems. These are signaled by an excessive amount of lepidolite occurring around the vug, all the lithium necessary to grow the desired gems was consumed by the lepidolite during the formative process.

The elbaite so sought after is a lithium-rich member of the tourmaline group. These occur in a variety of colors and color patterns, and are described with a distinct nomenclature. Rubellite is the red, pink or purplish-red variety. Indicolite is blue, whereas verdelite is the opaque green. Achroite is colorless, or almost colorless with just a hint of pink or green. Zoned elbaites are bicolored or tricolored, usually mixing some combination of red, pink and green. The famed watermelon tourmalines, first found at Mount Mica in Paris, combine a concentrically zoned pink and/or red core with a green outer zone or "rind." Likewise, cucumber tourmalines have a white or light-green center with a darker green rind. At a chemical level, the colors in these lithia tourmalines depend on the ratio of manganese to iron in the chemical lattice. A 1:1 ratio of Mn:Fe yields colorless, pinkish, and pale green crystals. More manganese than iron produces redder varieties, and more iron than manganese produces greener varieties. The abundance of these colorful gemstones has led to the development of a thriving gemstone industry. The beautiful watermelon tourmalines of Maine are now world renowned, but their journey to fame began about 180 years ago.

continued on next page

Collecting at Poland Mining Camps *from page 65*

Tourmaline was first discovered at Mount Mica in Oxford County in 1821, with the first official mineral mining beginning in 1822. These early mines were focused specifically on collecting the gem quality specimens such as the tourmalines, beryls and amethyst. After the Civil War, mining resurged as a major economic factor. The previous success of the gem mining ventures led to better organized efforts, including The Mount Mica Tin and Mica Co. in 1881 and the Maine Tourmaline Co. in 1904. The expanding economy found a market for commercial minerals such as mica and feldspar, and this emerged as a profitable approach to fiscally supporting the more tedious gem mining efforts.

The first feldspar refinery was established in Cathance in 1857, followed by a second in Auburn in 1897. Initial ventures to recover mica for commercial purposes were established in the 1890s, funneling mica by rail car to Connecticut for processing. These mineral operations, and the associated mills, were the impetus for many of the quarries in the Oxford and Androscoggin pegmatite region. Since the two types of mining had essentially grown up in tandem, miners would occasionally pause commercial mining efforts to recover substantial gem pockets. However, this was not always feasible, as evidenced by the treasures found in the dumps of these now silent quarries. An additional contribution to the gem and mineral world was the subsequent discovery of new, previously unidentified species. Some minerals that attribute their type locality to Maine include cookeite, identified at Paris and Hebron in 1866, hebronite, named for Hebron in 1872, and beryllonite, first retrieved at Stoneham in 1888.

These famous assemblages of minerals are historically attributed to the pegmatite environment. However, there are other rock environments in the general vicinity. In the extreme south of Maine are schists that bear kyanite, staurolite, and almandine garnets. A little to the north, where the original premorphed rock was limestone, the metamorphism produced calc-silicate rock, or skarn, yielding orange-brown grossular garnets, green diopside, and brown vesuvianite. The most notable accessible occurrence is near Minot, at the Pitts-Tenney Mine. These atypical occurrences are relatively small outcrops leading to very abbreviated prospects.

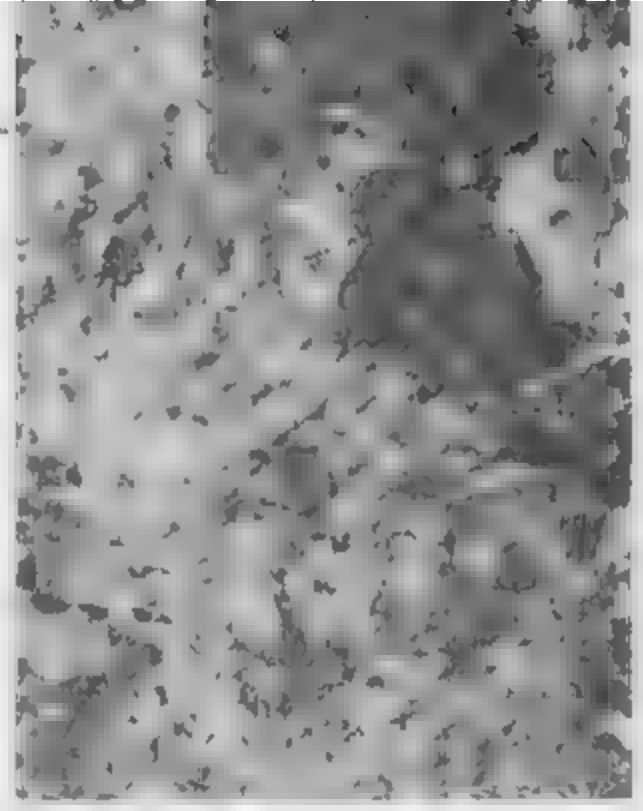
After researching the environments and the possible sites, we were ready to take up the invitation to collect. Our itinerary included stops qualified as "touristy," as well as "hard-core rockhound." Maine offers, in addition to minerals, many tourist worthy sites. Our journey to Poland Springs took us past several charming locations. Freeport, Maine, is synonymous with one of the world's premier catalog shopping establishments, L.L. Bean. We made a stop at the world famous store, stocking up on shoes and outerwear to be christened over the next few days in rock pits all across the region.

North of Freeport are two charming towns on the Androscoggin River, Brunswick and Topsham. Brunswick, on the south side of the river, is the home of Bowdoin College. Immediately across the bridge is Topsham. Once an important lumber and shipping center, Topsham now retains its historic district replete with gift shops. A trip to Maine would not be complete without venturing to the coast. From Topsham, it is just a few miles out to the Harpswells, small villages jutting out into Casco Bay.

Though the scenery and tourism were enjoyable, we did not leave the Topsham area without making some collecting stops. A well-documented site in the area is the Standpipe Hill location. The old pits are found behind a large water tank owned by the Brunswick-Topsham Water District. Reaching the two sites required a bit of a hike, we actually only spent time at one. The adit was pretty empty, with traces of biotite, mined from the pegmatites. A closer look at the tailings revealed a large chunk of granite pegmatite with what at first appeared to be large, weathered garnets, but more metallic. It finally hit me that they were magnetite crystals, for which the location is known, and wow, were they nice. They were ½ to 1 inches across and positively magnetic, with a slight covering of muscovite. Our son, Chris, began searching in the tailings that had been pushed down a steep hill and were now thoroughly washed. In a couple of hours, we found a dozen very nice magnetite crystals. We also retrieved a few nice pieces of biotite, and found a couple of dull brown almandine garnets before finishing up.

Two other sites in this general area are the Swamp quarries and Windham. The Swamp quarries of Sagadahoc County are famed for their black uraninite crystals. The pits are water-filled, but the uraninite can be found loose in the dumps. The radioactive mineral specimens are not easily found, and a small hand held Geiger counter is probably necessary to be successful here. Sites in the Windham area yield staurolite, as well as bladed blue kyanite. These seem to be unique sites, with minerals not really found elsewhere in Maine, and therefore worthwhile. Having had some positive prospects to begin our trip, we headed toward Auburn, then on to Poland.

I really did not know what to expect. The Poland Mining Camp consists of several very nice one- or two-bedroom cabins and a newly completed pavilion at the center of the cabin circle. The pavilion serves as the hub of camp activity, and houses the kitchen and dining room, a library of reference material about Maine, and a small museum with specimens

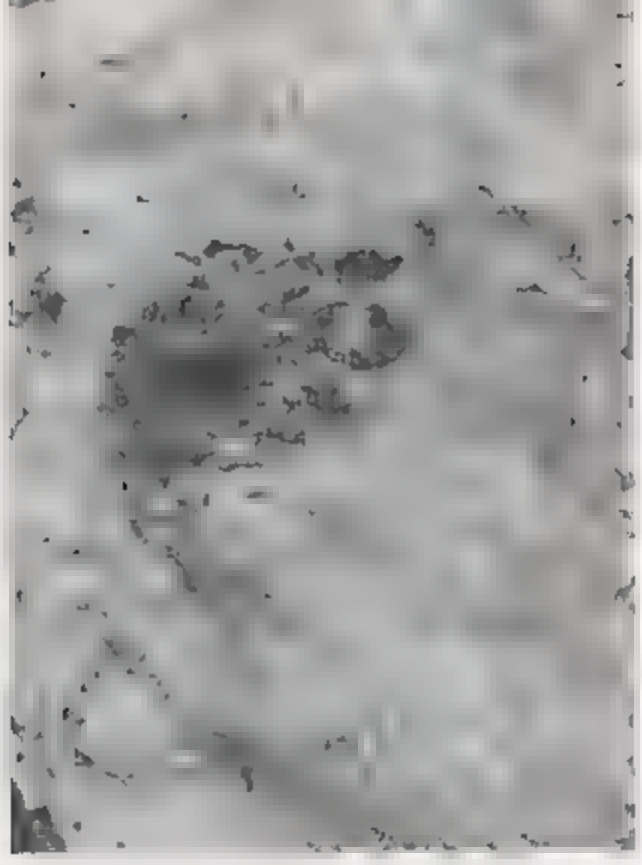


A wall full of schorl tourmaline in the Morgan Pit is representative of the richness of mineralization.

recovered from the region's famous mines: garnets from Minot, purple apatites from Paris, fine and beautiful lepidolite, tourmaline and beryls. There is even a stereoscope for material identification after a day of treasure hunting. During the evening hours Dudy, Mary, their guests, and area mine owners frequently chat over coffee about their finds, new and old. It is truly a haven for rockhounds. Mary prepares breakfast for camp guests and bag lunches for sustenance in the heat of the collecting day. Each day, one or two private locations are accessed, tailored to the customer's request when possible. Each evening, Dudy helps positively identify the specimens brought out, while Mary produces a fabulous dinner from roast chicken to Maine lobster caught the same day.

After a cool night's sleep in our cabin, we greeted the morning ready to collect. We went first to the Berry Quarry, currently under claim by Stephen Welsh, who actively mines the site. The Berry is a granite pegmatite that was originally explored by A.R. Berry of Auburn in 1900. In its youth, the quarry produced pink and green gem tourmalines. It is known for its rich green tourmaline, as well as what the locals call "tiger quartz," a mix of quartz and salmon-colored feldspar, which is mined in fair abundance at the site. Upon arrival, we immediately began finding some very nice schorl tourmaline. The primary matrix was albite, though we did find some very nice specimens of cleavelandite.

Cleavelandite, a variety of albite feldspar, occurs in very thin, platy crystals with a characteristic "open book" pattern, and appears pale blue-white when freshly mined, but bleaches to an opaque white upon prolonged exposure to the sun. It is named after Parker Cleaveland, the first professor of mineralogy at Bowdoin College in nearby Brunswick. In addition to the cleavelandite, we found two small almandine garnets in matrix, some fine-grained lepidolite, and some weathered, green (not gem-quality)



This large piece of cleavelandite with tourmaline embedded in it was found in the Hole-in-the-Ground Mine

tourmaline in matrix. Being fairly weathered, these could not be extracted without damage, so we brought them along in situ. We also found some of the signature salmon-colored feldspar, indeed striking in its color. My favorite find of the site was some small crystals of bertrandite, discovered after a session of rock breaking. Bertrandite, a pyrosilicate subtype of silicate, occurs in vugs deposited on top of albite or incomplete quartz crystals. The crystals typically have a "house of cards" formation of thin plates or tabular rhombohedrons. They have a pearly luster with striations. Viewed through a loupe, the specimen is quite interesting.

After a lunch break and an early afternoon siesta, we headed into Auburn to the eastern group of Mount Apatite quarries, the Maine Feldspar and the Greenlaw. These quarries have a noble history, yielding gem tourmalines that cut into beautiful stones. One specimen produced from these mines was purchased by Mrs. Andrew Carnegie for her personal collection. The Maine Feldspar has also produced some of the region's outstanding morganites, the pink gem variety of beryl. Mining at the two locations ceased in the 1930s, but collectors are allowed to frequent the dumps. As both quarries are now owned by the city of Auburn and serve as a recreational area for hiking, picnicking and collecting.

Though it was quite cool under the trees, the site only afforded us one find of note. After hiking a ways, we came upon a pit 4 to 5 feet deep that had been vigorously worked by someone, but was now abandoned. The previous collector left behind some very nice massive, foliated lepidolite, large chunks of a classic lithium purple color. Lepidolite is the lithium-rich variety of mica found frequently with gem tourmalines. Our biggest problem was deciding which ones to carry out, since the hike was long. But these specimens had exceptional form and rich color, so we loaded up and hooted it along.

For our second day, we headed to Minot to the Pitts-Tenney Quarry, also known as the Pitts Garnet Mine. This small deposit consists of calc-silicate minerals in metamorphic rock, a different suite than we found the previous day. The mine is known for its orange-brown grossular garnets. Dudy and Mary have some stellar examples in the pavilion, crystal clusters up to 2 full inches, nicely caramel colored. Most of the collected specimens are only partial crystals with a few faces protruding from the massive host rock, opaque rather than gemmy. The tailings are strewn up and down a fairly steep hill distal to the mine site. My husband and I slowly and deliberately began cracking the rocks, some massive grossular mixed with massive green diopside or clinochlore, expending much effort with nominal results. Our son was digging through the piles expending very little effort, finding small, semitransparent, gemmy, dark-orange garnets. We quickly adjusted our strategy, and soon we were digging under layers of mulch and leaves. We were reasonably rewarded, as we found several partial crystals in matrix. One good crystal had several exposed faces and was 1½ inches across.

The afternoon was unseasonably hot, so we rested again and then headed to West Paris to visit the famous Perham shop and quarries. The shop, located on state Route 26 at the state Route 219 West intersection, is full of beautifully cut gemstones of watermelon tourmaline faceted by talented members of the Perham family. Several generations of Perhams have played major roles in both the mining and gem cutting industries of this region. They currently allow collecting in five of their quarries. We visited two, the Waisanen and the Tamminen.

In the early 1960s, mining at the Waisanen produced some exceptional specimens of hydroxyherderite and beautiful parallel growths of smoky quartz crystals. The Tamminen produced pollucite and petalite (both rare) during the productive years in the 1940s and '50s, but is most known for the variety of unique quartz crystals discovered there. Smoky, citrine and milky quartz were staples here, but in addition to these doubly terminated crystals, scepter crystals, dressy phantoms, and crystals with movable bubbles were also found. The signature type, though, which is still sought, is the pseudocubic quartz crystal for which the site is renowned.

It was obviously a popular site, there were several collectors hard at work when we arrived. The heat was approaching 95 degrees, so our excursion was brief, but we did find a few milky quartz crystals. Someone mentioned that, earlier in the week, a novice collector had discovered a classic pseudocubic quartz crystal simply by looking down. Luck like that makes me green with envy. Oh, well, they are where you find them.

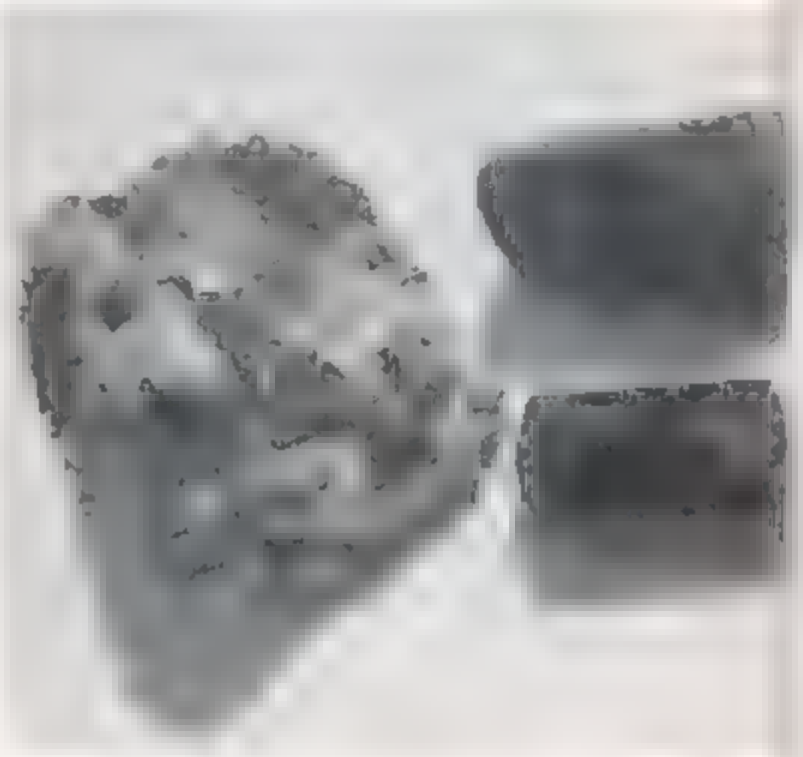
continued on next page

Collecting at Poland Mining Camps *from page 67*

Our third day was spent in Mary and Dudy's private quarries the Keith, the Dionne, and the Hole-in-the-Ground The Keith had schorl tourmaline and mica, and had recently been host to a find of some small gem tourmalines. These were unearthed with painstaking sifting The Dionne pit was cut with a basaltic dike, complete with porphyria, and hosted some small almandine garnets The most productive was Hole-in-the-Ground, as it had been blasted the previous spring Here we hunted, in the shade, for several hours Schorl, feldspar and quartz were abundant I settled myself on a tailings pile and began digging. I found several nice almandine garnets with almost gemmy red faces and a 2-inch opaque blue green beryl crystal with classic hexagonal form After some hard rock breaking, we discovered several decent specimens of bluish tourmaline in matrix, known as indicolite Not of gem quality, it still provided us with a third type of tourmaline to add to our collection of black schorl and green verdelite. The best finds of this site were classic to the area cookeite, gahnite and hydroxylherderite

Maine is the type locality for cookeite. A member of the chlorite group and containing, not surprisingly, lithium in its chemical structure, it was first observed at Mount Mica in Paris in 1830. It is abundant in gem pockets, and as coatings on quartz, feldspar and schorl I found several small, but classic pale-yellow, platy, pseudohexagonal crystals stacked in a continuous offset pattern forming a "jointed wormlike" structure These pieces were best appreciated through the loupe. The gahnite, a member of the spinel group, is a trademark of this site. My crystal was a floater, a deep olive-green octahedron covered with a thin layer of muscovite, as is common of the specimens found here The hydroxylherderite was nestled in a large piece of pure quartz. I almost missed it The two separate crystals, each about 1 inch in length and ½ inch across, had the usual chisel tip ends reminiscent of the herderites found in the Perhams' Waisanen quarry Both were pale yellow to colorless, with an oily luster that contrasted against the vitreous luster of the host quartz. Although some herderites in the region reportedly fluoresce pale yellow under short-wave UV, these specimens did not exhibit such fluorescence

On our fourth and final full day, we were privy to a real treat—a trip to an active new site The Morgan Pit was situated atop Noyes Mountain, several vertical feet above the Harvard Quarry, and was being worked by the Perhams Special arrangements had been made for the camp's guests to visit Lunches were packed and we headed out caravan-style The site was about 45 minutes from Poland When we arrived at the base of the mountain, my first concern should have been



Some of our best finds were these schorl tourmalines, loose and in matrix, from the Morgan Pit.

the "road" our guide was pointing out, though his greatest caution was about bears, "Just follow this road about two and a half miles to the top of the hill." Two and a half miles later I was longing for valium The road was really just washes—very rough, very steep—but our four wheeler delivered us to the top I was about to say something like "This better be worth it" when we crested and caught the view from the top. Simply breathtaking! The beautiful rolling, forested hills and the crystal blue lake in the distance almost made me forget the real treasures awaiting us.

The Morgan was really a small pit cut into the hillside The group dispersed, with each of us staking out our own section It was immediately evident that the pegmatite here was very coarse and rich with many different mineral specimens The pegmatite aficionado could pick up any rock from anywhere in the pit and identify three to five different minerals At first, the schorl tourmalines we found were pencil size, with excellent lines and terminations. Soon we graduated to thumb-size, well-terminated schorl. I was admiring one of these very nice specimens when my husband presented two schorl floaters that were almost fist size. It seemed that the wall at the back of the pit was checkered with the cross sections of thousands of schorl, some quite large

In a different area of the pit, visitors were seated collecting garnets by the jarful. A layer of compacted but well-defined almandines, roughly 6 inches to 2 feet thick in some places, cropped out in this area The garnets were easily plucked from the matrix without damage The garnets themselves, well formed brownish-red dodecahedrons, ranged from inch to 1 inch, with the occasional 2 inch prize

After working the walls awhile, and discovering the true meaning of "hard rock mining," I chose to work the tailings, cracking some of the bigger pieces This, too, was fruitful One large specimen, when broken, yielded four separate beryl crystals partially in matrix. These beryls, though not gem quality, displayed the classic hexagonal crystal habit and were a pale, opaque aqua One telling specimen had a layer of platy columbite, but was too big to handle When we broke it into smaller pieces, the interior taught an interesting lesson on the orderly deposition of minerals in these pegmatites The layers, stacked like a club sandwich, were clearly delineated by the presence of different minerals: columbite, then garnets, next small, opaque, pale-green apatites in a matrix of albite, then schorl tourmaline in a matrix of quartz Another specimen one of my favorites of the trip, was a chunk of nice cleavelandite plates sprinkled with delicate muscovite roses, enhanced when viewed through the loupe This specimen was very similar to samples Mary and Dudy had in the display cases back at camp

Knowing that we had to exit by the same "road" we came up, we carefully wrapped and packed our specimens and ventured forth, leaving this beautiful and productive site Undoubtedly, this was the densest, coarsest, finest pegmatite site I had seen in Maine. And the take from this site pretty much pushed the weight limit on our vehicle for the trip home

We packed up the next morning, but not without just one more stop Mary encouraged us to stop in at Mount Mica for a little sluicing So we said our thank-yous and goodbyes, and tagged along with the rest of the gang Mount Mica where tourmaline was first discovered in 1821, had not been active in quite a while However, within the past three years, some tourist collectors had uncovered a small pocket buried in an out-of-the-way wall with several, pencil size gem tourmalines inside In the quarry, the tailings were very fine, having been thoroughly worked We shoveled buckets and sluiced in a small spring-fed creek running through the pit Surprisingly, it was here that we finally found some very small, but classic, watermelon tourmalines Between us, we found three classic green tourmalines with pink centers, about nail size, though not very long Now we had at least a sample of almost everything for which the area was known Not a small task considering that many years of mining, re-mining, and rock hunting have tread on the same square feet of ground The trip was surely successful in terms of experience, scenery, bounty, and new friends made at Poland Mining Camps, all hosted by the pegmatites of Maine

ROCK SCIENCE

by Steve Voynick

Mining Magnesium

Remember how our high school chemistry teachers demonstrated chemical reactivity in metals by burning a magnesium ribbon in atmospheric oxygen? Amid an intense glow of brilliant white light, the thin strip of magnesium metal quickly oxidized into powdery, white magnesium oxide.

While magnesium metal oxidizes readily, reducing magnesium compounds to the elemental metal—a job necessary if we are to benefit from magnesium's many remarkable properties—is much more difficult.

As the sixth most abundant metal, magnesium forms 2.5 percent of the Earth's crust. Nevertheless, it remained unknown until 1808 when English chemist Sir Humphry Davy deduced that the base element of magnesium oxide was a previously unknown metal. Twenty years later, French chemists isolated magnesium as a highly active, ductile, silver-white metal with a relatively low melting point of 650 degrees Centigrade.

Structural strength and lightness are magnesium's most important properties. With a specific gravity of only 1.74, magnesium has one fifth the density of iron and two thirds that of aluminum. Despite the metal's obvious structural potential, it was long valuable only for its chemical compounds. Its oxide and carbonate were used in refractory brick for the metallurgical industries, while its chloride and sulfate (Epsom salts) served as feedstocks for chemical manufacturing.

Magnesium metal was used only in flares and pyrotechnics until the 1930s, when German metallurgists developed magnesium alloys for use as typewriter frames, aircraft wheels and brakes, and automotive gearbox casings. The United States had little interest in magnesium until World War II, when lightweight structural metals became strategically important for the manufacture of combat aircraft, triggering a rush to mine the metal.

Magnesium is present in hundreds of minerals, mostly in silicates, but the tight molecular bonding characteristic of silicates makes extracting the metal prohibitively expensive. Only three solid minerals have served as commercial sources of magnesium metal or its compounds: dolomite, or calcium magnesium carbonate, $CaMg(CO_3)_2$; magnesite, or magnesium carbonate, $MgCO_3$; and carnallite, or hydrated potassium magnesium chloride, $KMgCl_3 6H_2O$. All, however, present extraction problems.

Dolomite occurs in impure, massive form in huge sedimentary deposits of dolomite rock, which is similar to limestone. Dolomite is crushed and ground to a powder, then roasted to drive off carbon dioxide, CO_2, to produce large quantities of magnesia, or magnesium oxide, MgO, a valuable industrial compound. But magnesia's tight molecular bonding makes it difficult to reduce to metallic magnesium.

Magnesite is found in deposits of metamorphic serpentinite. From its compact, massive, white form, magnesite yields both magnesia and limited amounts of magnesium metal. But to extract the metal, magnesite must be fused with a silica-iron flux in a costly process.

Carnallite is an evaporite mineral usually associated with halite, or sodium chloride, NaCl, and potash. Because it must be mined either by costly underground or unreliable solution mining methods, it represents only a limited source of magnesium metal.

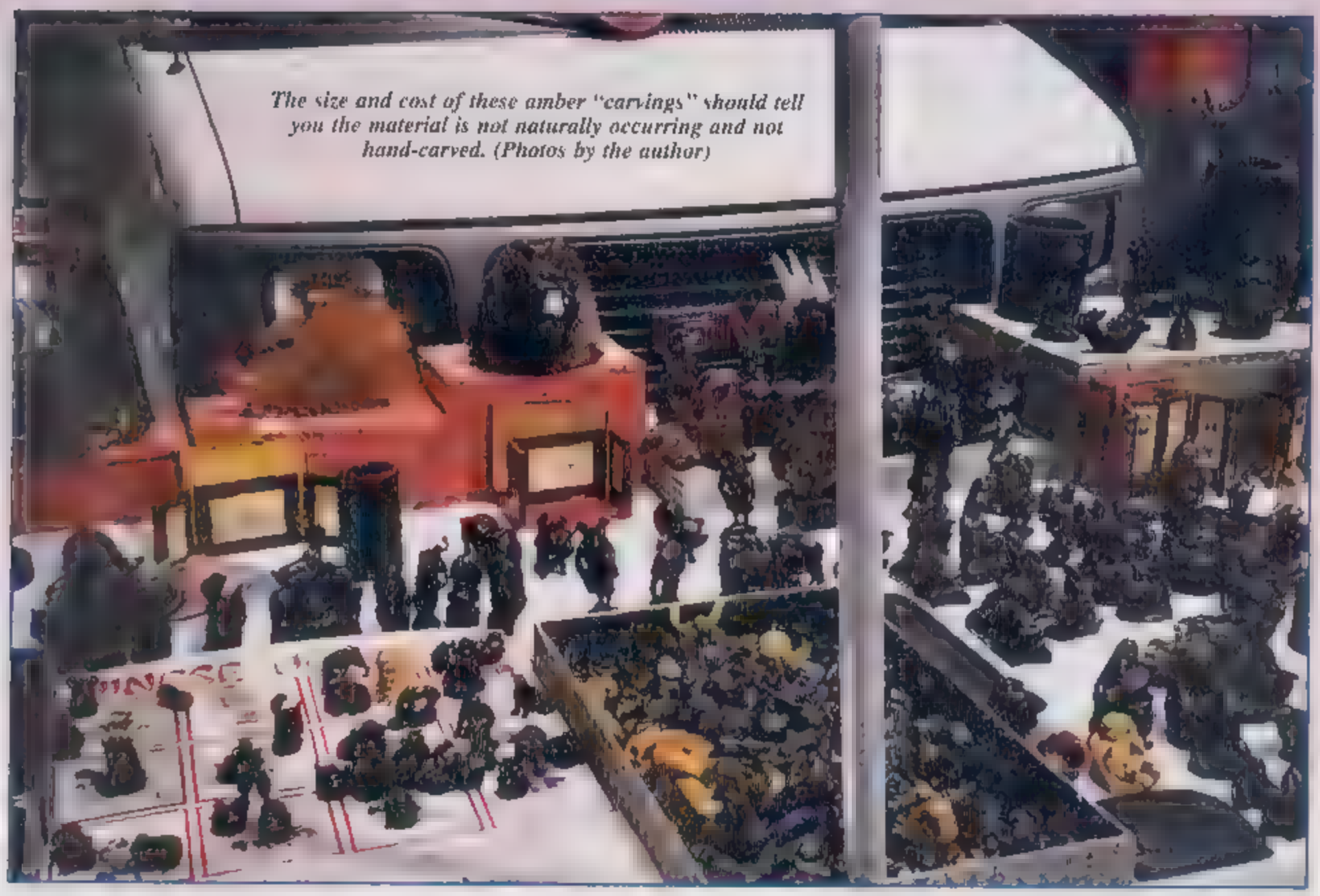
Interestingly, most magnesium metal is extracted from seawater and brines that are rich in magnesium and chloride ions. The biggest commercial 'deposit' of magnesium in the United States is actually Utah's Great Salt Lake, a terminal lake without outlets that loses water only through evaporation. Streams that drain nearby mountains, the lake's primary source of water, introduce more than 2 million tons of dissolved mineral salts—mostly sulfates and chlorides of sodium, potassium, boron, lithium, and magnesium—into the lake each year.

Because natural evaporation concentrates these salts, the brine of the Great Salt Lake today contains an estimated 150 million tons of dissolved magnesium chloride. And turning this salt into magnesium metal is a simple and inexpensive process. A large magnesium extraction plant first concentrates the brine in solar evaporation ponds, then separates the magnesium chloride from the other salts and flash dries it to a white powder. Electrolytic reduction of molten magnesium chloride produces highly pure magnesium metal—some 35,000 tons of it each year.

Most of that metal is alloyed with aluminum and manufactured into beverage cans and lightweight structural alloys for the aerospace industry—with enough left over to fabricate into ribbon for those ever popular chemistry class demonstrations.

SWAP MEET TREASURE HUNT

A Rock Shop Junkie's Guide to Swap Meets



The size and cost of these amber "carvings" should tell you the material is not naturally occurring and not hand-carved. (Photos by the author)

by Douglas S. Le Grand, G.G.

If you have been following the nine-article series on gemology (January through October 2003 *Rock & Gem*), you are ready to test your skills out in the field. In Part 9 of the series, I gave some examples of buying jewelry at a garage sale. Now, follow me as I go shopping for jewelry at a swap meet and see some ways your training will help you spot the deals and avoid the rip-offs. Over the years, I have met a few dealers who were more concerned with making a buck than the truth, and I hope this training will steer you away from their booths and toward the honest stone dealers.

The difficulties in establishing the authenticity of gemstones and jewelry in this type of marketplace are subtle. Imagine the beauty of an ocean, watching the waves crashing on the shore. What you don't see is the rip current underneath. As you wade in, the current catches you and drags you out to sea. This metaphor is a lit

Check gold objects for karat stamps. A 10k gold ring probably won't have an expensive stone set in it.

If the seller can't identify the stone, put your skills to work, and you may end up with a bargain.

tle dramatic, but hopefully you will keep it in mind as you go shopping for treasures.

Here is an economic joke: Two economists were walking along the sidewalk. One was younger and new in the field of research, while the other was an old-time professor of economics. The younger one spotted a $100 bill lying on the sidewalk and stooped to pick it up. The old professor stopped him with a strong pull on his shoulder. When the younger man asked why, the old professor cleared his throat and said it was obvious. It was not possible for the younger man to see the $100 bill on the ground, because it wasn't really there. If it was there, someone else would have already found it. I hope to prove the old professor wrong.

The difficulty with shopping at informal markets is that there are no regulatory agencies, no official or unofficial watchdogs guarding the honesty of the dealers and what they are selling, and little or no recourse for the buyer. In addition, the dealers are throwing up distractions, doing their best to draw your attention to their booth. An example of the trickery you will see is the display of a "Solid 14k" sign right next to a gold item, perhaps something you wish to purchase. This is one that I fell for recently. Why? Because I was listening to the woman's price and thinking she didn't know what she was selling. Boy, did I feel dumb when I took the ring to a jeweler and asked to have a stone set into the ring. He informed me that it was a 10k gold ring and wondered why I wanted to set an expensive stone into it. Yes, I felt dumb, and perhaps a little better prepared to educate others about such bait-and-switch techniques.

I recently bought several strands of pearls cheaply at a backyard rock sale. (These are often called widow sales, because it is usually the man who collects rocks against his wife's wishes, and on average, men die before their wives.) I was looking at two bags, each with several strands of pearls, for a couple of bucks each. Thinking that I was taking advantage of this poor woman, I bought them without stopping to ask if they were in fact real pearls. They weren't; they were plastic. Later, I went back to the woman and asked about the pearls. She claimed they were her husband's and she didn't know anything about them, and of course, she couldn't return the money. So beware of pearls sold in plastic bags, or anything that conceals or restricts your ability to inspect the items you want. The biggest hindrance is in your own mind. You must be aware of what you are buying and why. Inexpensive, nice imitation pearls are nice for a young woman, and the price was right, but it wasn't what I was looking to buy.

At a flea market, when you look at a plastic bag of what looks like nice jewelry, look as closely as possible for gold stamps guaranteeing purity. By law, any jewelry made or sold in the United States that crosses any state lines must be stamped with its gold carat weight. This is such a simple requirement that people, like me, believe what the paper tag on the bag says instead of looking for themselves. This assumption caused me to buy something other than what I was intending to buy.

The seller might not be so obvious as to put 14k solid gold on the paper tag, but it is common for a dishonest dealer to place a 14k solid gold card next to the bag. Remember, "14kgf" does not mean solid gold, but gold filled, which has a slightly thicker layer of gold plated over the base metal. Some jewelry will have the maker's name on it, such as Avon. This is not guarantee of gold carat weight. Be careful. If the jewelry is from Europe, it might carry its purity in percentage: .417 is 10k, .583 is equal to 14k, and .750 is 18k gold. Sterling silver is .925, while fine silver is .999. After you open the bag and find out that the rings you bought are not real gold, the dealer will tell you he is not going to return your money. Going to the promoter doesn't usually bring redress, as the dealer can say you must have swapped the rings or something. Caveat emptor—buyer beware.

So, why bother even going to the swap meet or garage sales? I don't want to be the old professor, telling you your dreams of bargains can't be true. A nice 10k solid gold ring should cost about $20 at the most in a flea market. I paid $20 for mine, and with a nice blue topaz, it made a great ring for my daughter. I recently bought a solid-gold ladies' wristwatch from a regular swap meet dealer. The watch's crystal was missing, plus the minute hand, but when I opened it up, it was stamped 14k, 1912 Waltham Bracelet. The dealer claimed that he felt bad about the axinite he sold me as tanzanite—not so bad that he was going to return my money—so he sold it to me for its weight in gold, $40.

I took the watch home and started to investigate its value in a Sotheby's book on watches. The closest I could find was a 1915 ladies' Waltham pocket watch for $1,500. My research also said that no Waltham ladies' wristwatches were made until 1915, which means that either the book was wrong or this was once a ladies' pocket watch that a jeweler converted into a wristwatch. A true rare find. Who says there aren't $100 dollar bills lying on the sidewalk?

This same dealer once sold me a rather large piece of "tanzanite" crystal for $20. I guess I never learn. It displayed trichroism—brown, yellow and colorless—was transparent, and weighed at least 75 grams. I didn't like the brown color, but natural tanzanite is brown before being heat treated, so I bought it and took it home to find out what it really was. Ever heard of axinite? The description given is "color often purplish brown, often confused with kornerupine, enstatite and zoisite; color, spectra, and pleochroism key to separation" (GIA Property chart B). I had the stone cut by a custom cutter and ended up with several rather large stones suitable for any true private gemstone collection. Now, I always look for this guy at the swap meet.

continued on page 90

ON the ROCKS

by Bob Jones

Faceters and Old Faithful

At the end of May, I was pleased to fly to Boise, Idaho, to be a speaker at the International/Northwest Faceters Conference, sponsored by the Intermountain Faceters Guild. Frank Markham headed up this delightful gathering. Having never attended such a conference, I really learned a lot. I'd be the first to admit I know little about faceting. Watching people sit at a machine, rocking a tool back and forth, and constantly using a loupe to check the condition of a facet doesn't much appeal to me; I'm more interested in the natural beauty of crystals. But I was very impressed by the extreme care and meticulous work necessary to achieve a near-perfect faceted gem. It was a real eye-opener. And this group of some five dozen experienced gem cutters expressed a very sincere dedication to their facet of the gem hobby.

Little did I realize the geometry involved with angles and facets. My high-school geometry hardly measured up! I told them when I left that I had not only learned a lot about faceting, but gained a very high respect for anyone who tackles this mathematical aspect of the hobby. The geometry of accomplishing a good faceted gem, the patience and dedication required, and the complete understanding of the equipment really requires a near-professional attitude and ability before choice gems result. So, I salute the fellows and ladies of this international group and all faceters who create for us the fantastic, sparkling beauties that start out as natural crystals.

Incidentally, I did admit to the group that I looked somewhat askance at people who take perfect natural crystals and saw them into blanks suitable for faceting. As lovely as the hidden gem is in a fine crystal, I just feel there are enough damaged or imperfect natural crystals that can give the faceter material to work with without dismembering nature's perfections. But then, I'm a mineral guy.

So, during my talks at the Faceter's Conference I commented a couple of times that it was something of a travesty to cut into a perfect crystal. In spite of the ultimate beauty of a faceted gem, as a mineral collector I am not convinced that faceting really exceeds the handiwork of nature. A natural, perfect crystal of any mineral has an innate beauty with greater appeal to me than a faceted gem. I admit I'm prejudiced.

Be that as it may, the conference was wonderful. The faceters are delightful people who listened to my position, then proceeded to discuss matters important to their hobby. Their displayed gems were stunning to say the least, evidence of superb abilities.

While in Idaho, I arranged to do other things. One plan was to visit America's premier national park, a geologic wonder that exceeds all others, Yellowstone Park. The timing was perfect, as the snow was virtually gone, but the hordes of tourists had yet to arrive. Traffic was insignificant and all the attractions, even Old Faithful, performed marvelously and were easily viewed and photographed.

Yellowstone Park is the surface expression of amazing geologic activity beneath the crust. It is the result of what geologists call a "hot spot" under the crust. Now, hot spots occur seemingly randomly in the crust of the Earth. One such has formed, and still is creating, the Hawaiian Islands.

A hot spot is a plume of molten rock rising within the Earth's crust. For all practical purposes, hot spots remain more or less stationary while the crust above slides along at something like an inch a century. If you look at the Hawaiian Islands, you'll note

The Yellowstone River carved the Lower Yellowstone Falls, over 300 feet high, and the colorful Grand Canyon. (Photo by author)

they form in a line from southeast to northwest, with most of the activity at the northern end. The hot spot remains where it is and the crust slides over it, and every time the hot spot builds up the strength and energy to force its way through the crust, another island is born.

The hot spot that has created Yellowstone Park hasn't always been under that area. If you study the geologic map of Idaho, you know the hot spot first burst forth to the southwest of Yellowstone. In fact, a series of some six major eruptions over a period of millions of years formed a chain of volcanic regions in a line starting southwest of Yellowstone. One eruption created the Craters of the Moon National Monument, acres of tortured and gnarled basaltic rock, skirted by vast areas of cindery ash slopes and symmetrical cones, created when the region was active.

The last three major eruptions in the Yellowstone region created three huge caldera. The first caldera is called Huckleberry Ridge. It formed just over 2 million years ago. Remember, a caldera develops after huge eruptions exhaust the support under the Earth's crust, making it collapse into a huge crater. The collapse put millions of tons of pressure on the remaining magma, and eventually a second series of eruptions created another caldera, called the Mesa Falls Tuff after the vast quantity of tuff rock it created. The final series of eruptions, about 640 years ago, created the Lava Creek caldera, the site of today's Yellowstone Park. This last series of eruptions spewed an unimaginable volume of rock to the surface, some 240 cubic *miles* of it. Sometime in the far, far future, the moving crust will position over the hot spot somewhere to the northeast of Yellowstone.

The composition of magma/lava can be either silica-rich, as is the case at Yellowstone, or silica-poor, as is the case in Hawaii. We call silica-rich lava rhyolite. It is Yellowstone's most common rock.

At Yellowstone, when the magma of the hot plume came close to the Earth's surface, it burst out in a tremendous explosion, releasing huge amounts of siliceous material into the atmosphere, spreading dust and ash as far as Iowa. Repeated eruptions gradually emptied the magma chamber under the crust, which, already badly faulted and cracked, collapsed into the near-empty magma chamber. That heated up the remaining magma, and surface flows were the result—in this case, flows of rhyolite. The ash and

gases that settled around the caldera earlier had formed huge layers of volcanic tuff, a glassy, light-colored rock that welded itself as it piled up layer after layer. This is seen as light-brown cliffs that dominate much of the park area.

Meantime, surface water worked its way down through the huge cracks until they came in contact with the super-heated rocks near the still-buried magma, some miles down. The water converted to steam, and this, in turn, exerted great force on the water clogging the cracks above. Because of the weight of the overlying water, the super-heated water below could not expand into steam. Eventually, this bottled-up force could no longer be contained, and with great force, abruptly expanded to throw a column of water out a surface vent as a spectacular geyser.

Of course, as the super-hot water—sometimes as hot as 290 degrees F—moved through crustal rocks, it had great dissolving power. Coming up through rocks high in silica, the water deposited silica rock, called siliceous scinter, or geyserite, on the surface. It is usually grayish white, porous, and in layers reflecting the intermittent eruptions of the geyser. The geyserite builds into conelike, sometimes oddly shaped vents that are, even without the geyser, very attractive. The entire area around what are now called geyser basins is a domed structure that looks like an upside-down shield.

If the super-hot water travels through limestone on the way to the surface, it brings dissolved calcium carbonate and, when it reaches the surface, forms what you might call a reverse cavern. In caves, the water drips form hanging stalactites and the like. On the surface here, similar waters deposit travertine terraces like the magnificent Minerva's Terrace, near Mammoth at the north end of the park.

While geysers are the darling of the park, my favorite area is around Mammoth, where lovely snow-white and colorful terraces of calcium carbonate form a high structure. Like a series of giant steps, these terraces have taken thousands of years to build, one thin layer at a time. Yet, it has been estimated some 2 tons of limestone calcium carbonate (travertine, if you prefer), are being built every day when the hot springs are fully active. The travertine builds like graceful, stepped curtains of stone, constantly changing and building, and pausing when the flow of water drops off.

Close by Minerva's Terrace and other travertine flows is perhaps the oddest formation you'll see. It's called the Liberty Cap, and is the exposed core of an ancient hot spring that stands 37 feet high. While surrounding limestone has been weathered away over hundreds of years, the harder core has remained as a reminder of earlier volcanic action.

The pools that form over vents that lack the water and force to become geysers bubble constantly, and are very colorful, as algae and bacteria thrive on the mineral-rich surface waters. The deeper pools hold stunningly blue water, as the dissolved minerals in the water reflect the sky beautifully. These pools are encircled, like a colorful necklace, by bright yellow, red or brown rings of the algae and bacteria that thrive here.

If these super-heated waters had passed through rocks rich in metals like gold, silver, lead, zinc, copper, and the like, we would see in Yellowstone the birth of hydrothermal ore deposits. That's what's happening at the black smokers, hot water geysering on the ocean's floor. The constant recirculation of waters here leaches metals from the rock and deposits them on the ocean floor in a process we now think created many metal-rich hydrothermal deposits we have worked these for many centuries.

But in Yellowstone Park, the super-heated waters that reach the surface, while they may pass through rocks containing metals, do not re-circulate again and again and do not add much to their metallic lode before finally surfacing. Minor exceptions to this rule occur, in one instance, at Hot Sulfur Spring. The waters have leached enough sulfur from the subsurface rocks to create a churning spring loaded with the yellow element. One vent just off to the side of this boiling cauldron wears a collar of bright yellow sulfur that has sublimated from hydrogen sulfide-rich gases coming from that little vent.

Elsewhere in the park, small evidences of sulfur can be seen as yellow streaks in the water trickling from some pools. In a few cases, the overwhelming odor of sulfur gases, most likely poisonous hydrogen sulfide, can be smelled around some of the more active vents like Black Growler.

Another volcanic feature here is what appear to be waterless vents. Hot gases gush forth from these openings, called fumaroles. The gases are largely carbon dioxide, the same gas that is dissolved in virtually all of Yellowstone's geyser and hot spring waters to form weak carbonic acid. The interesting thing about some of these fumaroles is that they growl, like gurgling breath being expelled.

A favorite spot of the ancient Indians is Obsidian Cliff, a huge formation of black volcanic glass some 200 feet high. Remember, rhyolite is a high-silica rock. When rhyolite lava bursts forth and cools very rapidly, it doesn't have time to form even the tiniest of crystals. Instead, it freezes into a glassy mass we call obsidian.

Obsidian breaks into wonderfully sharp fragments that can actually be sharper than razor steel! The early Americans realized this, and worked at Obsidian Cliffs to make hunting points and knives. The remains of their work lay scattered about when Jim Bridges and other trappers first came into area. Today, the area around Obsidian Cliffs is a protected National Heritage Site within a protected National Park. **No** collecting!

To complete the natural beauty of the park, the rivers here flow over hardened rock, gouge out the softer rock, and create marvelous rapids and waterfalls. Most spectacular are the Lower Falls of the Yellowstone River, which are at the head of the Grand Canyon. Plunging 300 feet into the abyss, these falls are spectacular and almost fearsome to behold. So is the canyon the river has created. With sides and slopes of bright yellow, rust red, stark white, and gentle yellow, this Grand Canyon, which stretches some 24 miles, is perhaps the most stirring and spectacular reach in the entire park.

While Yellowstone Park, established in 1872, became America's—and the world's—first national park, it also became America's largest natural animal preserve. The huge quantities of bison and elk are a site to behold. Black and grizzly bears search the region for food, while wolves stalk their prey. The American bald eagle dominates the sky, and trumpeter swans, Canadian geese, and a covey of colorful birds thrill the bird watchers who throng to the park.

There is something for everyone in the park—geologic history, human history, and a full range of natural wonders not seen in such quantity anywhere else in the world—thanks to Theodore Roosevelt, who first promoted the establishment of our wonderful park system.

My other plan was to visit a variscite mine high in the mountains west of Yellowstone Park. America has had several fine variscite deposits; Lucin and Fairfield, Utah, were perhaps the two best until now. The heavy snows of winter prevented me from reaching this new variscite deposit, but I've seen enough to know it is a treasure trove of wonderful lapidary material. Nodules upwards of 50 pounds have been mined here. The nodules are found in a clay zone and show a botryoidal, or lumpy, shape. Heavy equipment has to be used to gouge out the colorful treasures.

The variscite is a rich, deep green, far better than anything I've seen from Lucin and the equal of the best from Fairfield. Pieces that have been analyzed contain some copper (upwards of 20 percent), but iron dominates, so the material is true variscite.

The deposit was found by the grandfather of Paul DesFosses, my host, while the old boy was wrangling horses in the area back in 1913. Not much happened here until Paul came along, and now serious mining is under way. You'll see quantities of this variscite available in Tucson in February.

For $5, it would be worthwhile to buy this bola tie and take it home to test whether the green-patterned stone is something unusual.

Without all my lab equipment handy, it is nearly impossible to detect what dealers are selling, but you can at least narrow it down to something realistic. If the price is too low, double- and then triple-check your facts. If you can't come up with a real identity, figure out what the item is worth in its worst-case scenario. Any transparent, trichroic stone weighing 75 grams was worth $20 to me just to find out what it really was. Any solid 14k gold ladies' watch with extremely clean workings is worth $40, even for the scrap gold alone.

It turns out that this particular dealer travels a lot to New Mexico and buys from dealers who bring minerals across the border from Mexico. Axinite is often found in Mexico. This dealer apparently makes a living reselling items found in that locale in a more affluent market like San Diego. We later became friends, and often will meet at Quartzsite for a bull session of his travels. Many sellers at rock shows and swap meets make a living at what they are doing. This means they know what they have and they know what the real value of the item is and what they can get from you for it. So don't underestimate the person standing behind the counter, and remember, you must make your own determination of the true value.

One weekend, I decided to see what could be had in the way of jewelry at my local swap meet. I bypassed the silver jewelry stands, as they didn't seem to have many gemstones in their jewelry, and went straight for the second-hand junk dealers selling rings, watches, bracelets, and necklaces. When I began taking pictures of one display, the dealer ran up and assured me that he did not want his gold chains and things photographed. Hmm. What was he nervous about? From then on, I asked dealers if it would be OK to photograph their goods, and I didn't have any more problems.

One dealer was a retired lifeguard; Joe was his name, treasure hunting was his game. Very scientifically, he had discovered a method to uncover underwater treasures by learning how the fluid dynamics of the ocean and solid metallic objects reacted over time. I took several pictures of rings and old silver coins he had uncovered. He showed me the concretions (masses of jewelry and coins) before they were cleaned up and readied for sale. Of the 20 or so gold rings he had on his table, several had rather large red stones set in them. With your dichroscope, you could test the stones easily enough to see if they were garnets, glass, spinel, or ruby. You still couldn't tell whether they were real or not without some type of magnification. Natural rubies can be heat treated, irradiated, or diffusion treated. Sometimes, ultraviolet fluorescence can be used.

We didn't talk about using short- and long-wave fluorescence as a tool for detection in the series, but with synthetic rubies, it can be helpful. Synthetic rubies will glow bright orange-red, with flame fusion synthetic glowing brightest of all under long-wave fluorescence. Natural rubies will usually have a weaker brightness under long-wave. If you brought along your spectroscope, you'll see that rubies will have distinct doublet lines with direct transmitted light at 694.2 and 692.8 nm, and again at 668 and 659.2 nm, broad absorption from 620 to 540 nm, another doublet at 476.5 and 475 nm, and general absorption in the violet range.

You can use experience in natural gemstones as a rough guide. By this I mean rubies are rare, rarer than diamonds. Large, clean rubies that weigh more than 1 or 2 carats are rare and expensive, so when you see a ring with a 10 carat red ruby that you have tested with your dichroscope and shown to be double refractive, you can pretty much be certain that it is a synthetic corundum. Another big seller in the international tourist trade is giant, synthetic, color-change corundum that is sold as alexandrite. If you like the ring, and it has a clear gold carat stamp, and the price is based on $4 to $6 per gram of gold, then you can make a fair deal. Custom gold work usually costs $20 to $40 per gram, which makes a big difference in cost between two rings or earrings.

Joe also had several loose, colorless stones sitting on the table, so I asked him if they were diamonds. He said no. A quick see-through test on two of them substantiated that for me, but the third one *was* a diamond. What was its value? Now you need your 10X triplex loupe. I happened to find one down at Jeff's tool shed at the swap meet. (Besides 10X loupes, Jeff sells diamond cutting equipment, ranging from Dremel tools to large commercial hole saws used for gem mine exploratory work. If you have any commercial use for diamond-embedded tools, he can be reached at 858-945-4137.) I took my 10X loupe back to Joe's booth and inspected the diamond. It turned out to be a nice, ½ carat SI1 G color natural diamond. Joe was asking $800, same as the Rap sheet. Now how did he do that?

I continued my swap meet gem journey and came across an amber dealer selling authentic Baltic amber jewelry and collector pieces with insect inclusions—cool stuff at a reasonable price. He had a full mosquito inclusion for $49 that measured ¾ inch long, plus spiders, ants, and such for similar prices. He also sold a wide range of necklaces, tumbled and faceted stones, and a few silver pieces that had amber set into them. While walking around, I found several junk jewelry dealers selling bags of plastic and costume jewelry made out of miscellaneous materials. One gentleman was selling an old collection of bolo ties, set with huge green and transparent stones. He had no idea what they were. What if they were something rare like saussurite or chlorastrolite (pumpellyite)? I didn't carry enough money with me that day to buy them; he was only asking $5 each. Who knows what they really were? I guess I will never know.

Next, I came across a person selling Asian amber carvings. Exotic East was the name of the booth. He was selling an assortment of Asian knickknacks and huge, deep-red amber carvings, with finely carved Asian motifs. The prices were reasonable and the quality and color were excellent, and the material is basically amber. What is done is that the amber is dissolved and poured into molds. Then an artist goes back over the casting with a rough wheel, giving it a rough, carved look. They are beautiful to look at and the price was right, but real amber does not normally come that clear and in that color, nor in pieces large enough to make such large carvings. I didn't have any saltwater to test whether it would float, but it had very little heft to it, so I suspect it was amber and not plastic. I could have heated up a safety pin and touched the hot point to an area that was not visible to see whether I could smell a turpentine odor or an acidic plastic smell.

Well, I had a fun time at the swap meet. It didn't cost a lot of money, and I was able to visit several dealers all in one location and see several unusual items for sale. I was able to practice several gem identification tricks and hear some good stories. If that isn't a successful field trip, then I don't know what is.

The world of gemstones is exciting, with new discoveries of gemstones and enhancements every day. This is one field of study that is always changing. Any time you have a question or comment, please e-mail me at gemologist007@aol.com.